DOCUMENT RESUME

ED 188 148 CS 005 514

AUTHOR Danks, Joseph H.
TITLE Text Comprehension Processes in Reading. Final Report No. 1. September 1, 1979-August 31, 1979.
INSTITUTION Kent State Univ., Ohio.
SPONS AGENCY National Inst. of Education (DHEW), Washington, D.C.
PUB DATE Sep 79
GRANT NIE-G-78-0223
NOTE 97p.

EDRS PRICE MF01/PC04 Plus Postage.
DESCRIPTORS *Comparative Analysis; Elementary Education; Higher Education; *Oral Reading; *Reading Comprehension; *Reading Processes; *Reading Research; Reading Skills

ABSTRACT

Five studies compared how skilled readers arrived at an understanding of what they were reading with how children learning to read comprehended primers. Undergraduate, second, fourth, and sixth grade students read orally stories in which various aspects of the stories were distorted (pronounceable nonwords substituted for real words, semantically anomalous words inserted, sentences altered to produce factual inconsistencies). The oral readers' performances were analyzed for disruptions around the distortions. If there were several disruptions, then the reader must have been attempting to comprehend the distorted information. There were significant disruptions found with several different types of distortions. The pattern of the disruptions supported an interactive model of reading comprehension. Readers used many different sources of information to understand what they were reading. Comparing the children's results with those from skilled readers did not produce any differences in processing as a function of skill level. Children learning how to read were governed by the same reading comprehension processes when they read grade-appropriate stories. (Author/RL)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

ED188148

Text Comprehension Processes in Reading

Final Report No. 1

September 1, 1979--August 31, 1979

Joseph H. Danks

Kent State University

National Institute of Education

NIE-G-78-0223

September 1979

CS205514

Table of Contents

Abstract 1

Introduction 2

Experiment 1 9

Experiment 2 15

Experiment 3 23

Experiments 4 and 5 30

General Discussion 49

References 57

Footnotes 60

Appendices 61

Abstract

How do readers understand what they are reading? Since comprehension is the main reason for reading in everyday situations, comprehension is a general concern in our understanding of the reading process and the teaching of reading. The studies reported here investigate how skilled readers arrive at an understanding of what they are reading, and how children who are learning to read comprehend primers. Oral reading was used as the primary task for two reasons. One was that elementary school teachers frequently ask children to read aloud in class. The other reason was that the oral performance occurs at the same time that the reader is comprehending the story. Any difficulties in comprehension are reflected in the reader's oral performance.

The basic rationale was to distort various aspects of the stories, e.g., a pronounceable nonword was substituted for a real word, or a semantically anomalous word was inserted, or sentences were altered so that there was a factual inconsistency. Grade-appropriate stories were read aloud by skilled readers and by children learning how to read. The oral readers' performances was analyzed for disruptions around the distortions. If there were disruptions, then the reader must have been attempting to comprehend the distorted information. Across several experiments, there were significant disruptions with several different types of distortions. The pattern of the disruptions supported an interactive model of reading comprehension. Readers used many different sources of information to understand what they were reading. Furthermore, children learning how to read were governed by the same reading comprehension processes when they read grade-appropriate stories.

Introduction[1]

A distinction that has come to dominate information processing accounts of reading and language comprehension is between bottom-up and top-down directions of information control (Danks & Glucksberg, in press). Bottom-up processing proceeds from the "lowest," most concrete level of information nearest the sensory input to "higher," more abstract levels of representation. In its purest form, higher-level information never influences processing at a lower level and each lower level feeds information only to the immediately higher level. In top-down processing information flows in the opposite direction. Information represented at higher levels, either drawn from memory or resulting from processing decisions, influences processing at lower levels. Depending on the role granted the top-down processes, their influence varies between strong control, as in some analysis-by-synthesis models, to weakly influential.

Most of the information processing models of reading have emphasized bottom-up processing (e.g., Gough, 1972; LaBerge & Samuels, 1974; Massaro, 1975). Such models derive in part from an informal intuitive model that reading begins with perception of print and ends with an abstract form of representation at the next higher level. As the representation grows more abstract there is integration of units (usually adjacent ones) so that the integrated representation encompasses larger and larger segments of the text. This process can be a rigidly mechanical application of transformations, or a flexible and constructive integration, like solving a problem. Regardless of these differences, the emphasis is on interpretation and integration of meaning.

Strictly bottom-up processing models have difficulty dealing with two classes of phenomena. One class is the vagaries, ambiguities, and imperfections of typical human communication. To be successful with imperfect inputs, there must be a certain insensitivity and flexibility that bottom-up models typically do not possess. The other class of phenomena that poses difficulties is the facilitating effects of previous and concurrent contextual information. Numerous demonstrations exist that speed and accuracy of processing at one level is dependent on information from a higher level of representation (Rumelhart, 1977; Wildman & Kling, 1978-79). Letter recognition is facilitated by lexical information; lexical access (word recognition) is faster when syntactic, semantic, and factual information from sentences and paragraphs is available; sentence interpretation is aided by contextual information about the topic or theme; and paragraph interpretation is aided by general world knowledge. One or two of these contextual processing interactions might be handled plausibly by modifications in a basically bottom-up model, e.g., by the addition of feedback loops or the reorder-

ing of processing stages. But the pervasiveness of top-down effects throughout all levels of representation indicates that the basic bottom-up conception is inadequate.

There have been few purely top-down models proposed as alternatives to bottom-up models and with good reason. Bottom-up effects can be demonstrated. Information from lower levels does find its way into higher-level representations. We do not make up the meaning of what we are reading. As a general principle, whenever processing is difficult or unfamiliar at a given level, there is a greater emphasis on processing lower-level information first. However, if the text is not too difficult or unfamiliar, top-down information can facilitate processing greatly. The key to the benefits of top-down processing lies in the tremendous redundancy that is present at all levels of representation. While redundancy tends to bog down any attempt at comprehensive bottom-up processing of all the information in the signal, it opens the door to more efficient selective sampling guided by contextual constraints.

The most realist alternatives to bottom-up models are interactive models that permit both bottom-up and top-down directions of information flow (Danks, 1978). However, because of the traditional dominance of bottom-up models, interactive models have concentrated on describing how top-down information functions interactively. In order to demonstrate the interaction clearly, interactive models have focussed on intermediate levels of processing so that both directions of processing have an opportunity to function. The most common intermediate level is lexical access or word recognition. Visual information operates bottom-up on lexical access and syntactic, semantic, and sentence-content information operates top-down.

Selection of lexical access as the focus of study may not be the most felicitous choice, however. There seems to be a fundamental change in the nature of the comprehension process as lexical access is finished. Words and letters can be thought of as self-contained units possessing a relatively enduring identity. It makes perfect sense to talk about word and letter "re-cognition" processes because we encounter those same units repeatedly. Beyond the level of words, however, a somewhat different picture emerges. Sentences and paragraphs do not have the same kind of permanent identities that we attribute to letters and words. Since almost every sentence a reader encounters is unique in his experiences, it does not make sense to talk about a sentence "re-cognition" process. The correspondence between the physical input and the mental representation is much less evident once we move past the word level.

Oral Reading Task

Oral reading is a task used frequently in schools for the teaching and evaluation of reading (Durkin, 1978-79), but we understand very little of its processing requirements and how it relates to silent reading (Danks & Fears, 1979). In contrast to silent reading, oral reading requires as its dominant demand that each word be recognized in serial order so that it can be verbalized. In most oral reading, processing probably is carried beyond simple word identification, but higher-level comprehension is not the central focus. In contrast, silent reading does not require the serial recognition of every word, but typically focusses on more global comprehension.

When oral reading is followed by a comprehension test, e.g., recall, summarization, or question answering, there are two major tasks confronting the reader (Danks & Fears, 1979). One is to verbalize each word in succession. To accomplish this task he must recognize each word. By this we presume that he locates the word in his mental lexicon and then uses the articulation procedures represented there to pronounce it. It is possible that a reader might use solely lower-level information such as grapheme-phoneme correspondences, spelling patterns, or syllabic structure, to pronounce each word without accessing it in the mental lexicon. However, since readers do not "read" pronounceable nonwords unhesitantly, complete dependence on lower-level information is unlikely.

The reader's second task is to understand phrases, sentences, paragraphs, and themes of the text so that he is able to satisfy the demands of the comprehension test. Here information from several levels must be integrated to construct a reasonable interpretation of the text. During oral reading, the reader is attempting to satisfy both the verbal performance and the comprehension tasks at the same time, but the press of the performance demand is greater. Thus, analysis of oral performance provides an excellent opportunity to study both word recognition and story comprehension in a relatively natural reading situation.

Oral reading has the advantage of yielding a continuous on-line response that is roughly contemporaneous with the visual input. It is the reading counterpart to shadowing speech. In shadowing, the listener is presented with continuous speech and must produce the corresponding verbalization immediately while continuing to receive new input. In oral reading, the reader produces a verbal response corresponding to the print input immediately after receiving that input. The main difference is that in shadowing the input is not under the control of the listener as it is in oral reading, but this difference corresponds to the difference between listening and reading generally.

Experimental Rationale

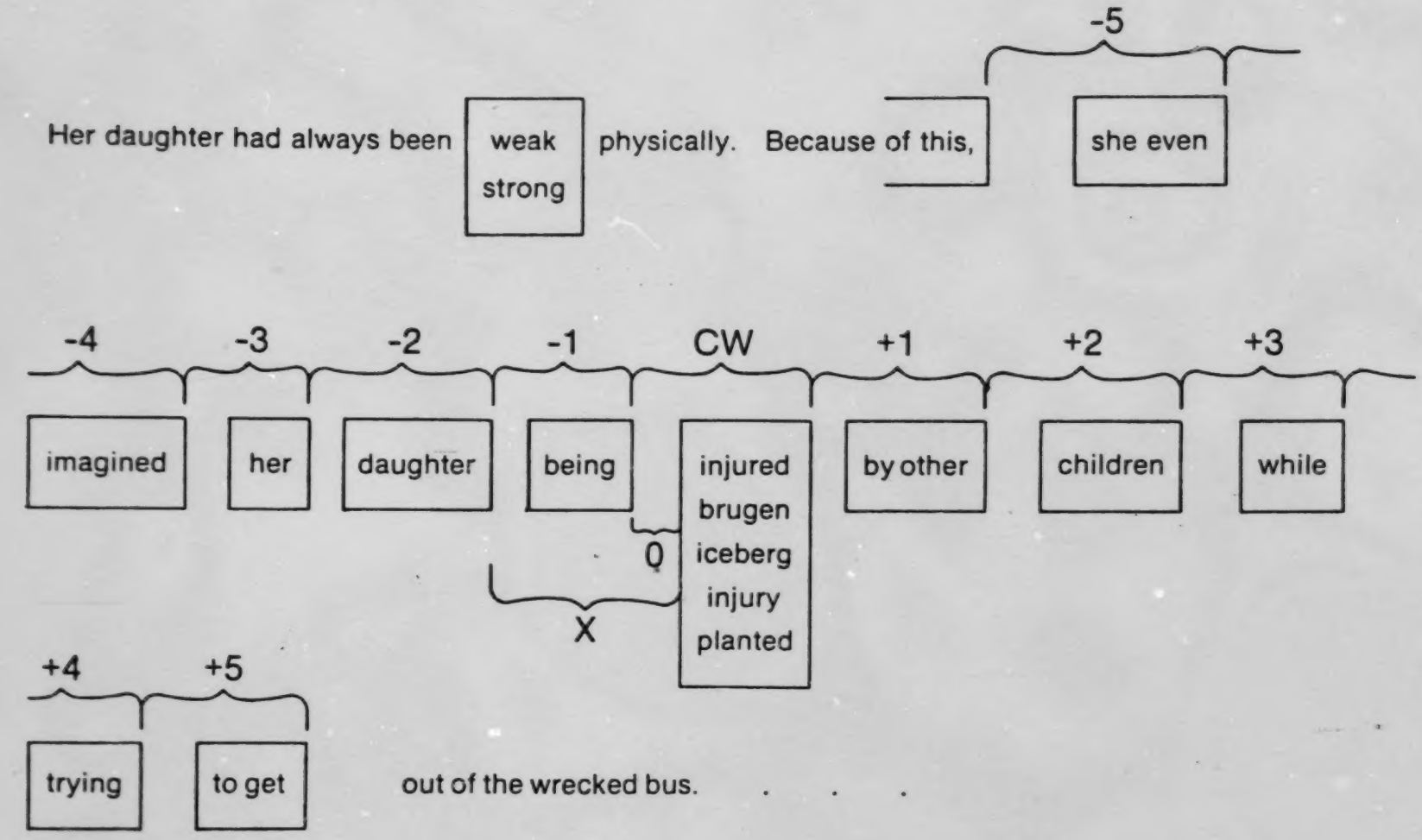
How different types of textual information are used in oral reading was assessed by violating or removing the information from the text. If that type of information is used in meeting either the verbal production or the comprehension task demand, there should be a disruption in the oral performance. Additionally, that disruption should be located temporally close to the time when the missing or violated information was needed by the reader. Thus, our basic task was to alter several critical words in a long story. The critical words were modified such that one or more types of textual information was removed or violated. We then analyzed readers' oral productions for disruptions at or around each critical word.

Across several experiments, using readers at different levels of reading skill (defined by grade), we have manipulated lexical, syntactic, semantic, and factual information as follows. These manipulations are illustrated in Figure 1 with a segment of text from the college student story. The story is about a high school girl that is severely injured when a train hits her school bus. In the example, her mother has just heard about the accident and is worried about the daughter.

(a) Lexical. The critical word (injured in the example text) was replaced with a pronounceable nonword (brugon). The nonword followed the rules of English orthographic structure and was readily pronounceable. If the reader were relying solely on grapheme-phoneme correspondence to pronounce the word, there would be no disruption of his oral performance. But if the reader were using lexical information, word recognition would be impossible because the nonword was not in the reader's mental lexicon. In addition, the lexical violation would disrupt comprehension as well, because no syntactic or semantic information was associated with the nonword.

(b) Syntactic + Semantic. Both syntactic and semantic information was distorted by replacing the critical word with a word that was the incorrect part of speech and which was semantically anomalous as well (iceberg in Figure 1). Here the word could be accessed in the mental lexicon, but it is inappropriate for the syntactic and semantic context of the sentence.

(c) Syntactic. Syntactic information alone was distorted by retaining the root of the critical word, but changing the inflection such that it indicated a part of speech that could not occur at that point in the sentence. In the example in Figure 1, injured, a verb, was changed to injury, a noun. Although some semantic information is carried



-6-

Figure 1. A portion of a story for college student readers illustrating the different types of textual manipulations.

in the syntactic categories, certainly most of the semantic information remains in the root. In this case, the reader could determine the meaning of the text relatively easily.

(d) Semantic. To violate semantic information, but not disturb lexical or syntactic information, the critical word was replaced with a word that was the correct part of speech, but which was semantically anomalous, e.g., planted replaced injured. While the reader can determine grammatical structure, he has to concoct an implausible meaning. The best he can do is to imagine some very unusual circumstances such that the anomalous word could be interpreted metaphorically.

(e) Factual. Factual information is what the reader accummulates from the proceeding text as he reads a story. As he reads he constructs a representation of what the writer is telling him. New information is added to that representation. Factual information was violated by introducing an inconsistency between the critical word and the preceding sentence. Unlike the other manipulations, neither the critical word nor the sentence containing it was altered. The sentence immediately preceding the sentence with the critical word was modified such that the critical word was factually inconsistent with the information of that sentence. In the example in Figure 1, the word weak in the preceding sentence was replaced with strong. The fact that her daughter was strong was inconsistent with the mother worrying about her being injured. There was nothing syntactically or semantically wrong with either sentence. They simply communicated inconsistent information.

All modifications were selected such that there was no conceivable continuation following the critical word that would resolve the distortion. For the factual manipulation, we checked that there existed a plausible substitution for the critical word. Otherwise, the reader might sense something was amiss prior to reading the critical word. For example, if the daughter were strong, the mother might imagine her being safe, unharmed, helpful, or even a heroine.

The basic rationale was to look for disruptions in oral reading performance surrounding each of the violation types. If there were disruptions in oral performance, then the reader was using that information to recognize the critical word and to construct a meaning for the text. Furthermore, the relative position of the disruptions resulting from the different violations would indicate the order in which the information is typically used.

According to a bottom-up model, only lexical information is strictly necessary for oral production, although the reader would need to determine the grammatical structure to read with appropriate prosody. If the reader were using solely grapheme-

phoneme correspondences to pronounce the words and did not access the word in the lexicon prior to uttering it, then the disruption from the lexical violation would occur after the critical word had been said. Syntactic and semantic information would be used primarily at the end of the clause when the meaning of the clause was determined, so those disruptions would occur after the critical word around the clause boundary. Violations of factual information would be important only after the meaning of the clause had been determined. The reader would attempt to integrate the meaning of the clause with the representation of the preceding text, and then encounter the inconsistency.

How syntactic, semantic, and factual information exerted top-down influence on lexical access would depend on the particular interactive model adopted. If syntactic, semantic, and/or factual information were used in lexical access, then disruptions from violating that information would occur at about the same time as those resulting from lexical violations. Whether the disruptions occurred at the same position and had about the same extent would indicate relations among the information sources. Violating two information sources, as in the syntactic + semantic manipulation, would lead to different patterns of disruption depending on the interactions among the information sources.

Experiment 1[2]

In Experiment 1, skilled readers were tested with paragraphs containing lexical, syntactic + semantic, and semantic violations.

Materials. Fifteen paragraphs were selected from a contemporary novel. Although the passages were not contiguous in the novel, they were from the same portion and the temporal sequence was maintained. The paragraphs averaged 124 words long and had a readability of 6.0 (Fry, 1968). The first three paragraphs were used as warm-up paragraphs. The remaining 12 paragraphs contained either a lexical, syntactic + semantic, or semantic violation or was a control paragraph. There were four different versions of each paragraph representing each of the experimental manipulations. The replacements for the original critical words were critical words from other paragraphs that had been removed from that paragraph or were in the control condition. The set of words used as substitutes were the 12 critical words and three nonsense words, counterbalanced across versions so that no subject saw a critical word twice except in the control condition. The substitutions were counterbalanced across nouns, verbs, and adjectives.

The four versions of each paragraph were assembled into four sets such that within each version set, each manipulation occurred three times, once as a noun, verb, and adjective. The sets were complementary so that each manipulation occurred once in each paragraph across versions.

The paragraphs were typed on separate pages and arranged such that the critical word did not occur near the beginning or end of a line. The sentences with the critical word and the three modifications are presented in Appendix A.

Subjects. The subjects were 13 male and 27 female undergraduate students from general psychology classes at Kent State University. They were volunteers and received points toward their grade for participating. All were native speakers of English, but they were not screened for reading ability.

Procedure. Four experimental groups were defined by the four sets of paragraphs. Each set contained three instances of the four types of modification (control, lexical, syntactic + semantic, and semantic) crossed with the three parts of speech (noun, verb, and adjective). The specific paragraph containing each type of manipulation was different in each set. Each of the four groups of readers received complementary sets such that all paragraphs were tested in all experimental conditions across groups.

The 40 subjects were randomly assigned to the four experimental groups with 10 subjects in each group. Each subject was tested individually. The reader was seated at a table with a microphone in front of him/her and the experimenter was seated to the side, out of the reader's sight. The readers were told that the purpose of the task was to look at the relationship between reading and comprehension. The readers were instructed to read each paragraph aloud. After reading each paragraph, the subjects were required to summarize it orally in a few sentences. They were given as much time as needed to read and summarize each paragraph. The reading performances and summaries were tape recorded for later analysis.

Each student read three warm-up paragraphs that contained no modifications followed by 12 experimental paragraphs. Because there were no changes in the three warm-up paragraphs nor in the three control paragraphs, a total of only nine critical words were altered out of 15 paragraphs (1860 words).

Analyses. The text surrounding each critical word was divided into word units. The flow of speech is such that we do not speak each word as if in isolation with a distinct beginning and ending sound. What occurs is a blending of some beginning and ending sounds. This blending of sounds makes it difficult to detect breaks in the utterances of one word to another. The result of this variation is two words may be uttered as if they were one long word with no break separating them. Likewise, there are some words that are pronounced with a break in the middle, depending on the particular configuration of phonemes. Word units were an attempt to reflect actual speech production in this oral reading task.

A word unit was defined as a word or group of words pronounced or read as a unit with no pause within the unit. Word units typically consisted of one or two words (rarely three words). They were determined by listening to all of the readings of 16 subjects, four from each group. The text surrounding the critical word was divided into word units for each of the 16 subjects. The most consistent phraseology used by the majority of readers was adopted. Word units did not necessarily follow the syntactic structure of the sentence. Five word units before and five word units after each critical word were marked. Of the 120 word units, 62 were one word, 55 were two words, and 3 were three words long. These word units are indicated in the example in Figure 1 and in the segments presented in Appendix A.

The dependent variable was the frequency of a major disruption at each of the word unit positions as a function of experimental manipulation. Major disruptions were defined as pauses of at least one sec. duration, substitutions, omissions, reversals, stammerings, mispronunciations, repetitions, and regressions. In short, any deviation from fluent oral reading

that indicated that the reader noticed a violation was scored as a major disruption. Only one disruption was scored per word unit.

Two analyses were conducted on the major disruption data, one which collapsed across subjects and one which collapsed across the three segments having the same manipulation. It was necessary to collapse in these ways because the basic data consisted of ones and zeros, corresponding to whether a specific reader produced a disruption at each word unit position in each paragraph. Both subjects and critical word segments were random factors. In the analysis that collapsed across subjects, segments was the error term, and in the analysis that collapsed across segments, subjects was the error term. In both analyses the within-subject and within-segment variables were modification type (4 levels) and word-unit position (11 levels). The effect of interest was the interaction of modification type and word-unit position. This interaction provided information concerning the relative magnitude of disruptions and their temporal ordering. All effects reported as significant were with $p < .05$, and individual comparisons were planned comparisons using an F test.

Results and Discussion

The mean frequency of a major disruption as a function of modification type and word-unit position is shown in Table 1. These frequencies were converted to probabilities by dividing by the number of subjects times the number of replications of each modification (40 x 3 = 120). The probability of a major disruption at each position in the control condition was subtracted from the probability of a major disruption in each experimental condition. The interaction between modification and position represents the magnitude of the disruptive effect at each position and is graphed in Figure 2.

Both the main effects of type of modification and word-unit position were significant in both analyses: modification, F_{sub} (3,108) = 21.83, MS_{sub} = .243, and F_{seq} (3,24) = 9.96, MS_{seq} = .177; and word-unit position, F_{sub} (10, 360) = 31.30, MS_{sub} = .257, and F_{seq} (10,80) = 21.42, MS_{seq} = .125. However, both main effects need to be interpreted in terms of their significant interaction, F_{sub} (30,1080) = 9.56, MS_{sub} = .289, and F_{seq} (30,240) = 5.71, MS_{seq} = 1.612. The critical values for a significant difference between individual means were .078 for the subjects analysis and .102 for the segments analysis.

As shown in Figure 2, the disruption from the lexical violation occurred at the critical word itself (word unit 0). Most of these disruptions were pauses as the readers hesitated before uttering the pronounceable nonword. They balked at not being able to locate that lexical item in their mental dictionaries, and sometimes had difficulty pronouncing the non-

Table 1

Experiment 1: Mean Frequency of a Major Disruption

	Word Unit Position										
Condition	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Control	7	14	10	23	14	7	5	13	7	6	7
Lexical	5	14	5	14	24	65	39	23	10	5	8
Syntactic + Semantic	5	9	9	7	21	54	41	26	9	10	10
Semantic	6	5	15	10	15	11	21	21	15	8	10

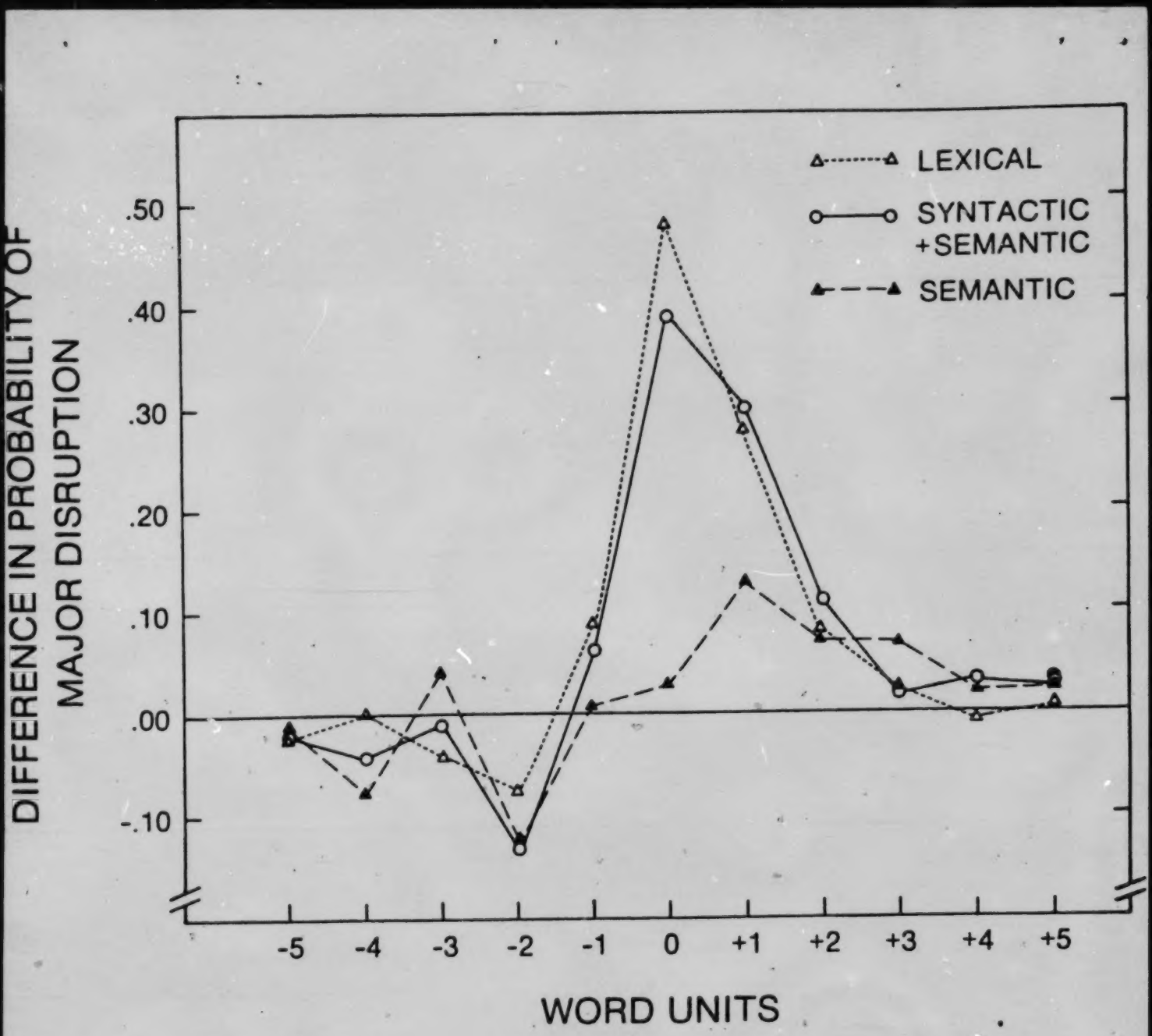


Figure 2. Experiment 1: Differences in the probability of a major disruption.

words just on the basis of the grapheme-phoneme correspondences. The disruptions from the syntactic + semantic violation followed the disruption from the lexical almost perfectly. They both differed significantly from the control at the critical word and at word unit +1. Syntactic or semantic information or both were being used to locate the lexical item, so that removal of that information disrupted the readers. Because the pattern of the syntactic + semantic disruption was essentially the same as the lexical, these information sources must have been active at the same time.

The disruption from the semantic violation did not occur until word unit +1, however, and was significantly smaller in magnitude. Evidently in this story, semantic information was not being used for lexical access, but the violation was discovered later, perhaps when clause integration occurred. Syntactic information, in contrast, was being used to locate the lexical item, so that its violation led to a disruption in oral performance. When we considered the story more carefully we realized why the semantic information may not have been used as easily. The story was excerpted from a novel that was written in a very abstract style using many figures of speech. The semantic violations were anomalies that easily could have been mistaken for intentional metaphors. The readers adopted the quite reasonable strategy of not giving high priority to semantic information because it was frequently nonliteral or anomalous.

Experiment 2^3

There were two major changes between Experiment 1 and this one. The text was an emotionally involving story about a high school girl who was severely injured when a train hit her school bus. Although the semantic violation was manipulated in the same way as in the first experiment, the general context of a concrete, literal story should make the semantic violations more effective. The second change was the introduction of factual violations instead of lexical ones. The addition of a factual violation permitted the comparison of intrasentence integration (syntactic + semantic and semantic violations) with intersentence integration (factual violation).

Method

Materials. The text was adapted from a story in a popular magazine. It was rewritten to eliminate all conversation and any difficult or infrequent words. The final story was 2171 words long and its readability was 7.8 (Fry, 1968). It was divided into four sections of approximately equal length and four critical words were selected in each section. An average of 129 words separated each critical word. Syntactic + semantic and semantic substitutions were selected for each critical word. For the lexical violation, the sentence preceding each critical word was altered such that there was a factual inconsistency with the critical word. The segments of text surrounding each critical word including the manipulations are presented in Appendix B.

As in Experiment 1 four versions of the story were arranged such that each violation occurred at each critical word segment in one version. There was one violation of each type (syntactic + semantic, semantic, factual, and control) in each section of the story. The manipulations were distributed in a counterbalanced manner such that there were an equal number of violations of each type at each segment in each section across versions. In contrast to Experiment 1, there were 16 critical words, so that there were four replications of each violation in each version.

Each section of the story was typed starting on separate pages. Critical words did not occur in the top or bottom three lines on each page. The critical words were also at least three words from the beginning and end of the typed lines.

Subjects. Subjects were 11 male and 29 female undergraduate students enrolled in general psychology courses at Kent State University. They received points toward their grades for their voluntary participation. All were native English speakers, but were unscreened for reading ability.

Procedure. The procedure was basically the same as in Experiment 1 with the following exceptions. There were no warm-

up paragraphs or story; however, there were 185 words before the first critical word occurred. This portion of text should have provided sufficient warm-up for the readers. The readers wrote a summary after each quarter of the story instead of giving an oral one after each paragraph.

Analyses. As in Experiment 1 the segment of text surrounding each critical word was divided into word units following the same principles as were used in Experiment 1. The word units averaged 1.54 words long and are marked on the text segments presented in Appendix B.

Major disruptions were scored using the same criteria as in Experiment 1, and were analyzed with two analyses of variance, collapsing across subjects making segments the random error factor and collapsing across segments making subjects the random error factor.

A second dependent variable was the production time for each word unit. These times were measured by slowing the tape recorder to half-speed. An experimenter then pressed a key at the end of each word unit beginning with the end of the sixth word unit before the critical word (see Figure 1). A PDP 8/I lab computer monitored the key presses and timed the latencies between them. Each interval included the production times for the word unit and any pause, hesitation, or filler that preceded the word unit or was included within it.

Since the critical word physically changed between the control, syntactic+semantic, and semantic conditions, the production times for the critical word itself were not comparable. An additional latency was measured from the end of word unit -2 to the beginning of the critical word unit (labelled "X" in Figure 1). The production time for word unit -1 was subtracted from the additional word unit "X". This difference (labelled "O" in Figure 1) corresponds to the time between the end of word unit -1 and the beginning of the critical word unit. The value of "O" was used for the critical word unit production time in all analyses.

Because of the possibility of experimenter error in measuring the production times, intra- and inter-experimenter reliabilities were obtained. The same experimenter retimed four randomly selected subjects' protocols about a month later. The two measurements for each segment were correlated. The average correlation was .98. Seven randomly selected subjects' protocols were measured by a second experimenter; the latencies for each segment were correlated with those from the first experimenter. The average correlation was .94. Thus, the procedure for measuring production times was quite reliable, both within and between experimenters.

The production times were analyzed with a mixed analysis of variance with five factors. Groups of subjects defined by

the four versions was a between-subject factor. Subjects and segments were random factors, both of which were nested in groups. Type of manipulation and word-unit position were within-subject and within-segment factors. This design permits calculation of a quasi-F (F') as advocated by Clark (1973), in which both subjects and language materials are considered as random factors contributing to a single error term. All reported effects were significant with $p < .05$. Individual comparisons were planned comparisons tested with an F test.

Results and Discussion

The mean production time as a function of violation and word-unit position are presented in Table 2. However, since the word units differed markedly in absolute physical size, the more important results are the differences in production time between the experimental conditions and the control condition. These differences are depicted in Figure 3.

The effect of primary interest for the hypotheses was the interaction between violation types and word-unit position. This interaction was significant at $p < .10$, $F'(30, 371) = 1.374$, $MS_e = .745$. However, since the individual comparisons were planned, they were calculated at $p < .05$. The critical difference in mean production time was 190 msec. (The interaction was significant at $p < .05$ using only subjects in the error term, $F(30, 1080) = 9.163$, $MS_e = .223$, critical difference in means = 73 msec.)

Both the syntactic + semantic and the semantic conditions diverged from the control at word unit -1. However, the syntactic + semantic condition peaked at word unit 0, but the semantic disruption did not peak until word unit +1. Both conditions continued to stay above the control through word unit +3. The factual inconsistency produced a much smaller effect, and was significantly different from the control at word units +1 and +2 using only subjects in the error term, but not using the quasi-F error term.

The mean frequency of a major disruption as a function of violation and position is presented in Table 3, and the difference in the probability of a major disruption between the experimental conditions and the control condition is depicted in Figure 4. The main effects of type of violation and word unit position were both significant both in the subjects analysis and in the segments analysis: violation, $F_{sub}(3, 108) = 72.996$, $MS_{sub} = .312$, and $F_{seg}(3, 45) = 36.438$, $MS_{seg} = 1.519$; and word unit position, $F_{sub}(10, 360) = 35.712$, $MS_{sub} = .439$, and $F_{seg} = (10, 150) = 12.647$, $MS_{seg} = 3.007$. However, both effects can be interpreted only in light of the significant interaction between them, $F_{sub}(3, 1080) = 12.157$, $MS_{sub} = .369$, and $F_{seg}(30, 450) = 8.632$, $MS_{seg} = 1.254$. The critical values for a significant difference between means in the interaction were .066 for the subjects analysis and .078 for the segments analysis.

Table 2

Experiment 2: Mean Production Time (msec.)

	Word Unit Position										
Condition	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Control	596	430	501	578	355	146	454	511	509	405	477
Syntactic + Semantic	549	449	489	609	621	586	791	700	636	448	553
Semantic	567	431	460	605	463	299	819	686	671	432	567
Factual	586	456	478	568	372	168	553	602	516	424	508

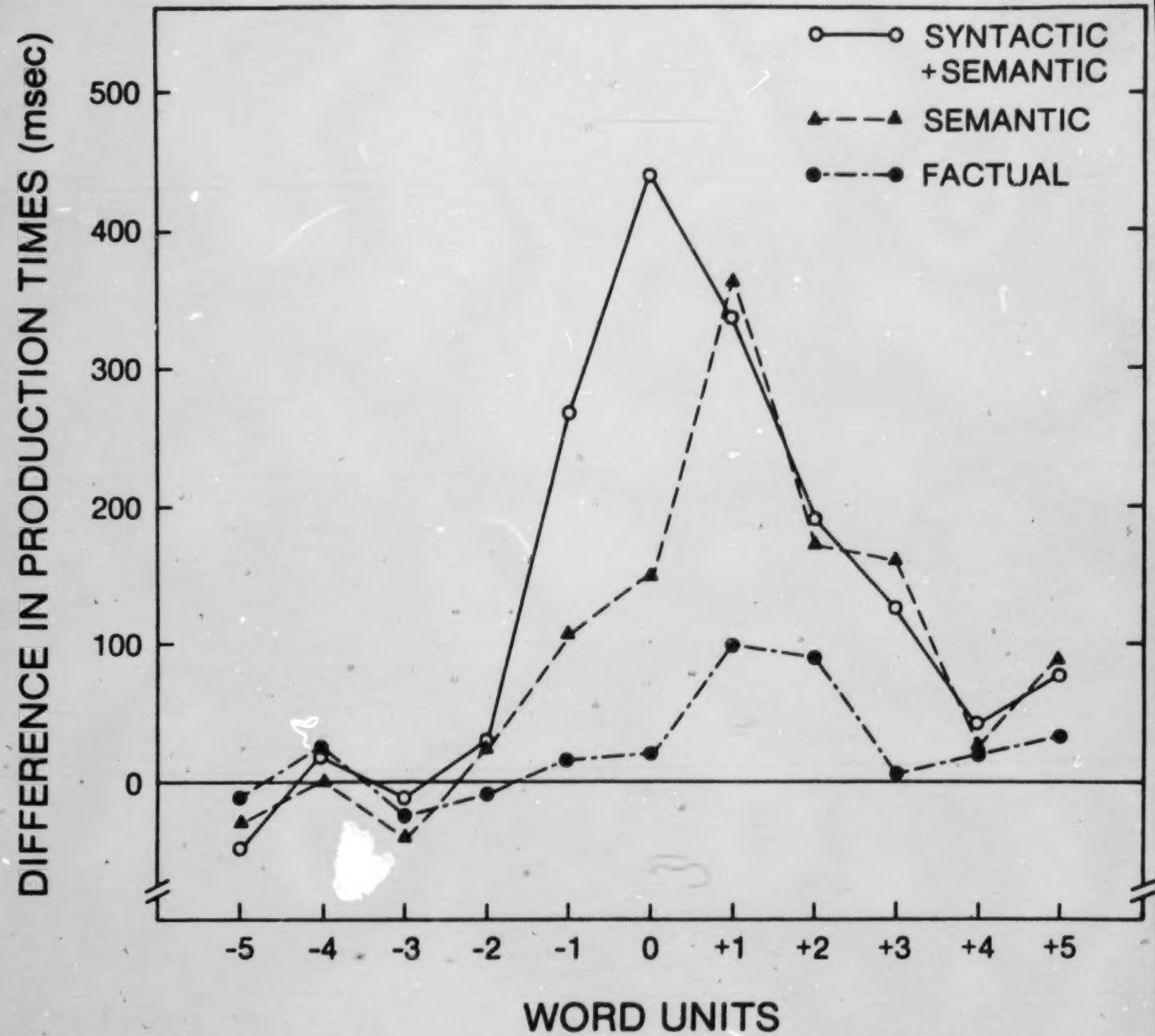


Figure 3. Experiment 2: Differences in production times.

Table 3

Experiment 3: Total Frequency of Major Disruptions

Condition	Word Unit Position										
	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Control	8	8	11	8	12	14	8	18	14	7	12
Syntactic + Semantic	10	8	13	13	43	104	49	36	23	14	16
Semantic	12	7	9	15	28	57	58	36	34	15	24
Factual	12	7	12	10	14	20	21	21	15	16	19

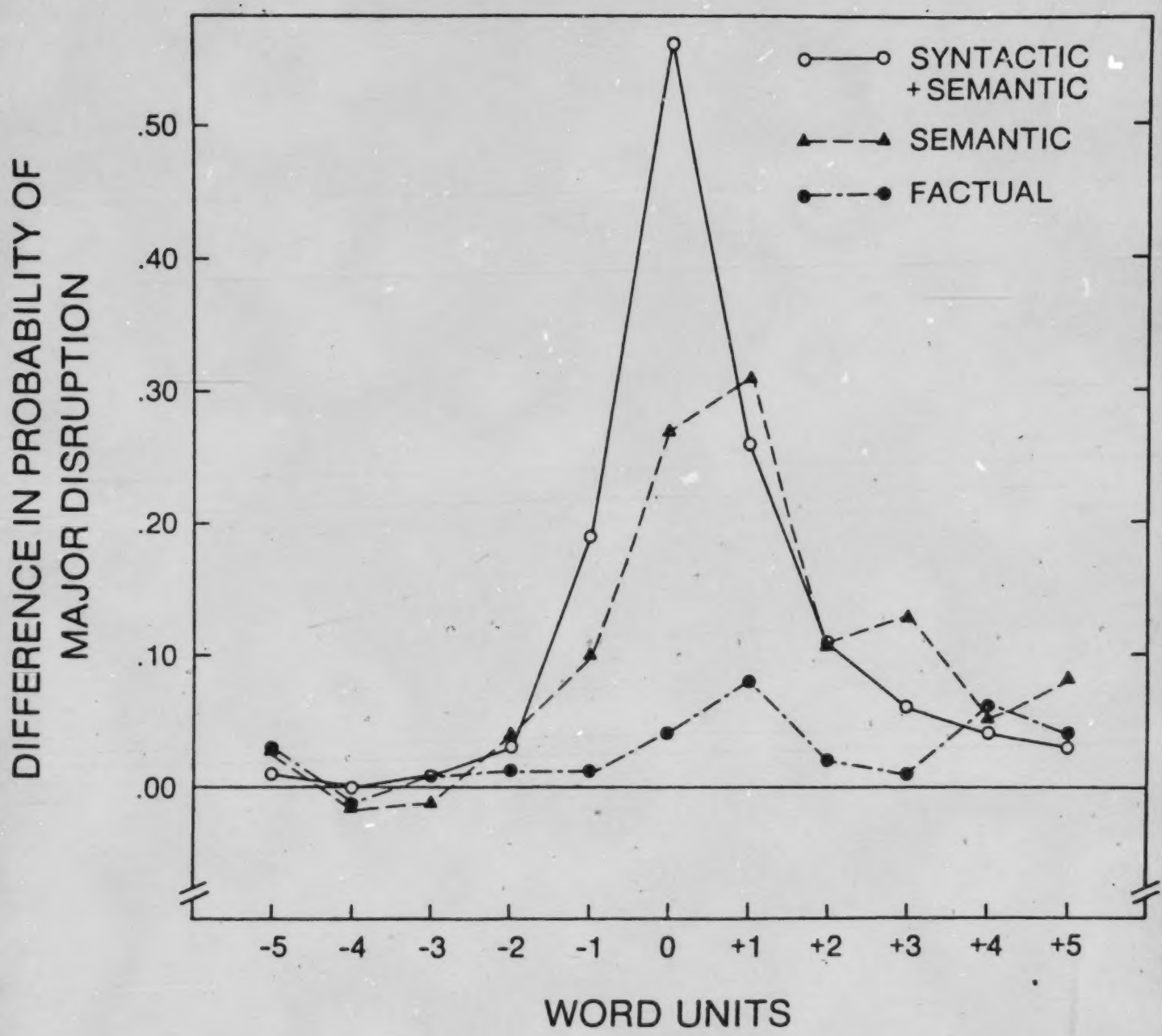


Figure 4. Experiment 2: Differences in the probability of a major disruption.

Both the syntactic + semantic and the semantic violations produced a disruption at the word unit before the critical word (word unit -1, see Figure 4). The disruption from the syntactic + semantic violation was significantly larger than that resulting from the semantic violation alone, but the semantic violation had a longer lasting effect, remaining significantly different from the control at word units +3 and +5. Since both syntactic + semantic and semantic violations yielded disruptions before the critical word was produced, both syntactic and semantic information was being used during lexical access. Both violations were also disruptive after the critical word was produced indicating failure during the comprehension-integration task as well. The factual inconsistency was disruptive only after the critical word had been uttered (word unit +1). So factual information was not involved in lexical access, but only in intrasentence comprehension and intersentence intergration.

The syntactic + semantic violation had a larger disruptive effect earlier than did the semantic violation, suggesting that the syntactic + semantic violation was a violation of two independent knowledge sources. If syntax and semantics constitute two relatively independent sources of information that are processed by two different comprehension subprocesses, then this confounding of syntactic and semantic violations in a single manipulation can account for the relatively greater disruption and the earlier peak of the syntactic + semantic violation relative to the purely semantic violation. If two independent information sources were violated, a violation in one of them would be noticed before a violation in either one by itself. The next experiment separated violation of syntactic and semantic information and attempted to enhance the factual violations.

Experiment 3[4]

Experiment 3 was a close replication of the previous one. The story and the critical words were the same. The syntactic + semantic violation was replaced with a syntactic only violation, and the semantic violation was retained. This change permitted a direct comparison of when the syntactic and semantic information sources were used and whether they seemed to be used independently or not. Additionally, several of the factual inconsistencies were rewritten in an attempt to enhance the factual disruption so that it could be located more precisely.

Method

Materials. The text used in this experiment was identical to that used in Experiment 2 with the following exceptions. Several of the factual inconsistencies were altered such that the inconsistency seemed more striking, at least to the intuitions of the investigators. For the syntactic violation, the base morpheme of the critical word was retained, but the inflection was changed so as to produce a word that was unambiguously the incorrect part of speech for the sentence. The segments of text used in this experiment plus all of the manipulations are reproduced in Appendix C.

Four versions were constructed as in Experiment 2. There were a couple of minor modifications in the specification of word units resulting from the analysis in Experiment 2. These word units are marked in Appendix C.

Instead of asking for summaries, multiple-choice questions were prepared for each quarter of the story. These tested literal, factual knowledge of the story that was not involved in the manipulations. There were 10 multiple-choice questions for each quarter except there were only eight questions for the third quarter. Readers were very accurate on these questions (over 95% correct), and there was no variation across quarters or versions. The results are not discussed further.

Subjects. The subjects were 17 males and 23 female undergraduate students enrolled in general psychology courses at Kent State University. They received points toward their grades for their voluntary participation. All were native English speakers and were unscreened for reading skill.

Procedure. With the exception of the use of a multiple-choice test, the procedure was identical to that used in Experiment 2.

Analyses. The analyses of the oral productions was virtually identical to that in Experiment 2. Only four word units before the critical word were scored. The slightly altered

word units averaged 1.60 words long. Both production times and major disruptions were scored. However, due to problems with a laboratory computer the production times have not been submitted to analysis of variance. The production time means are presented here and interpreted under the assumption that the analysis of variance and the critical differences between means are not too different from those obtained in the Experiment 2. For this reason, the interpretations of the production times must be viewed as only preliminary.

Results and Discussion

The mean production times as a function of violation condition and word unit position are presented in Table 4 and the difference in mean production times between the experimental conditions and the control condition are depicted in Figure 5. The results were very similar in many ways to those of the Experiment 2. The syntactic and semantic conditions both produced increased production times beginning at word unit -1 and continuing through word unit +3. However, in contrast to the preceding experiment, the curves followed each other almost exactly, peaking at word unit +1 (the same as the semantic condition in Experiment 2), except that the effect in the syntactic condition fell off a bit faster at word units +2 and +3.

The disruption from the factual inconsistency was larger although it still was not as large as that produced by the syntactic or semantic violations. The factual disruption was spread over three word units (+1 through +3) instead of two, and the peak was approximately 60% higher than it was in Experiment 2.

The total frequency of a major disruption as a function of violation and position is presented in Table 5. The difference between the experimental and control conditions in the probability of a major disruption is shown in Figure 6. As in the preceding experiments, the main effects of violation condition and word unit position were significant in both the subjects and segments analyses violation; F_{sub} (3, 108) = 63.524, MS_{sub} = .332, and F_{seg} (3, 45) = 25.620, MS_{seg} = 2.059, and position, F_{sub} (9, 324) = 50.693, MS_{sub} = .416, and F_{seg} (9, 135) = 21.845, MS_{seg} = 2.416. The interaction of violation and position was also significant in both analyses; F_{sub} (27, 972) = 20.311, MS_{sub} = .388, and F_{seg} (27, 405) = 16.694, MS_{seg} = 1.181. The critical values for a significant difference between individual means of the interaction were .068 in the subjects analysis and .076 in the segments analysis.

As can be seen in Figure 6, the syntactic and semantic violations produced very similar disruption curves. Both were significantly different from the control at word unit -1 and peaked at the critical word. The semantic violation produced

Table 4

Experiment 3: Mean Production Times (msec.)

	Word Unit Position									
Violation	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Control	410	540	620	355	140	500	565	470	425	550
Syntactic	440	545	595	435	415	890	690	555	455	580
Semantic	425	540	630	460	405	850	750	620	480	580
Factual	415	530	660	415	175	655	650	585	415	515

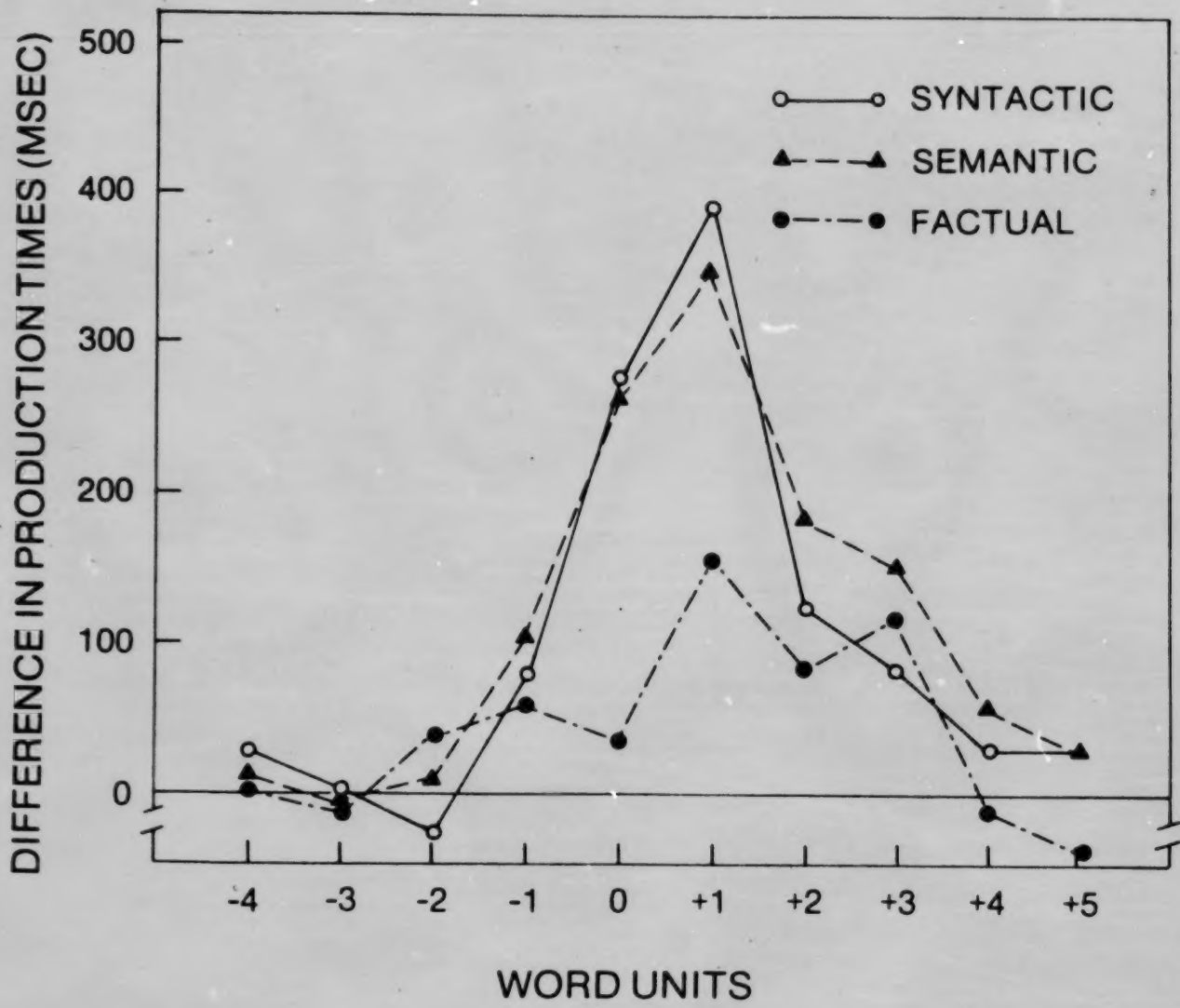


Figure 5. Experiment 3: Differences in production times.

Table 5

Experiment 3: Total Frequency of Major Disruptions

	Word Unit Position									
Violation	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
Control	11	12	16	11	11	13	9	11	11	19
Syntactic	8	9	11	31	125	52	27	29	11	14
Semantic	5	11	10	29	70	58	33	27	17	21
Factual	8	14	14	18	13	30	20	20	4	9

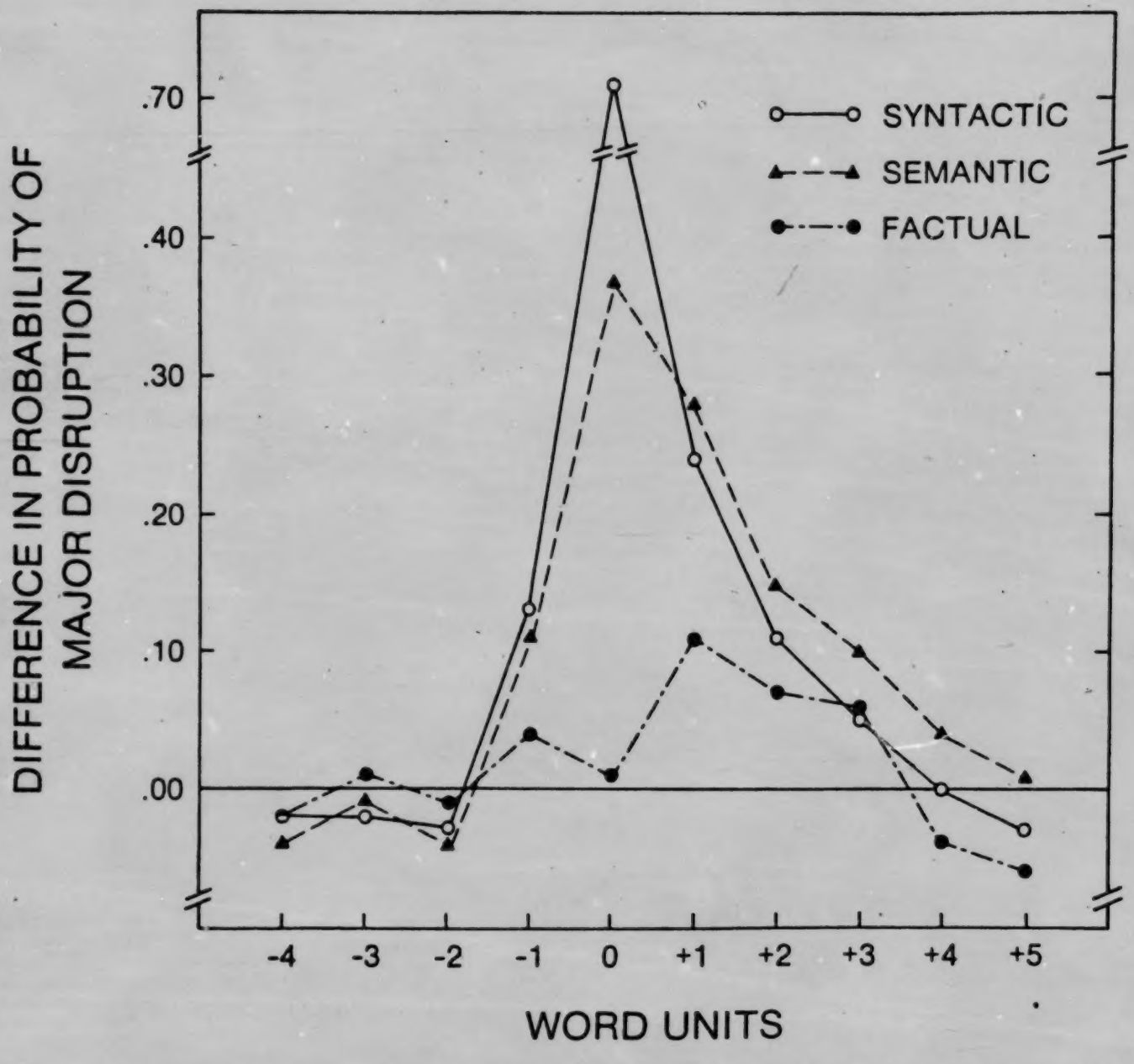


Figure 6. Experiment 3: Differences in the probability of a major disruption.

a slightly longer disruptive effect (to word unit +3) than the syntactic (only to word unit +2). The biggest difference was in the magnitude of the disruption at the critical word. Most of the disruptions in the syntactic violation (54% of all disruptions) were substitutions of the base word with the syntactically correct part of speech. Excluding restorations of the original critical word from the syntactic and semantic conditions, the proportion of disruptions at the critical word were virtually identical--.33 for syntactic and .34 for semantic. The restoration of the original critical word in the syntactic violation condition was very clearly a top-down effect. Readers were reading to make sense out of the text. While the substitution occurred at word unit 0, the production peak was at word unit +1 (see Figure 5). Readers apparently were substituting the original word in their productions because that was the word they were expecting and the first several letters satisfied those expectations (cf. the restoration effect obtained by Marslen-Wilson & Welsh, 1978, in a speech shadowing task). After they said the syntactically restored word, they realized that it was not what was printed and then hesitated or paused increasing the production time of word unit +1. This pattern is a clear instance of a top-down effect. The original word was anticipated and produced. The failure of a bottom-up confirmation check against the visual text caused a subsequent disruption.

The factual violation produced a larger effect than in the preceding experiment; it was first effective at word unit +1. In contrast to syntactic and semantic information, factual consistency did not have any apparent influence on lexical access of the critical word. However, it did influence integration and comprehension of the sentence meaning. Whether that effect occurred at the clause boundary or at an earlier point in the sentence is discussed in a later section of this report.

Experiments 4 and 5[5]

How do information sources interact as a child is learning how to read? One hypothesis is that the child pays most attention to bottom-up information because that is where most instruction is focused and that is where the child is having the most difficulty. As bottom-up processing becomes more automatic (LaBerge & Samuels, 1974), the child gradually is able to use more abstract information for lexical access and meaning integration. Alternatively, speculation could run in the opposite direction. Initially the child might be overly dependent on context and prior knowledge to recognize words and understand texts simply because of his/her lack of proficiency in processing bottom-up information. As he/she gains skill in decoding, bottom-up information would become relatively more useful to him/her and the balance between bottom-up and top-down processing would shift.

To begin to investigate these questions, the basic experimental paradigm used with skilled readers was adapted for children learning to read--second, fourth, and sixth graders. Experiment 4 was a pilot study that evaluated the reasonableness of using the oral reading procedure with children and assessed the stories developed for use with children. Experiment 5 was a full-scale experiment using the procedures and stories only slightly modified from Experiment 4. Because of the similarity in materials and procedure, the two experiments are presented together.

Method

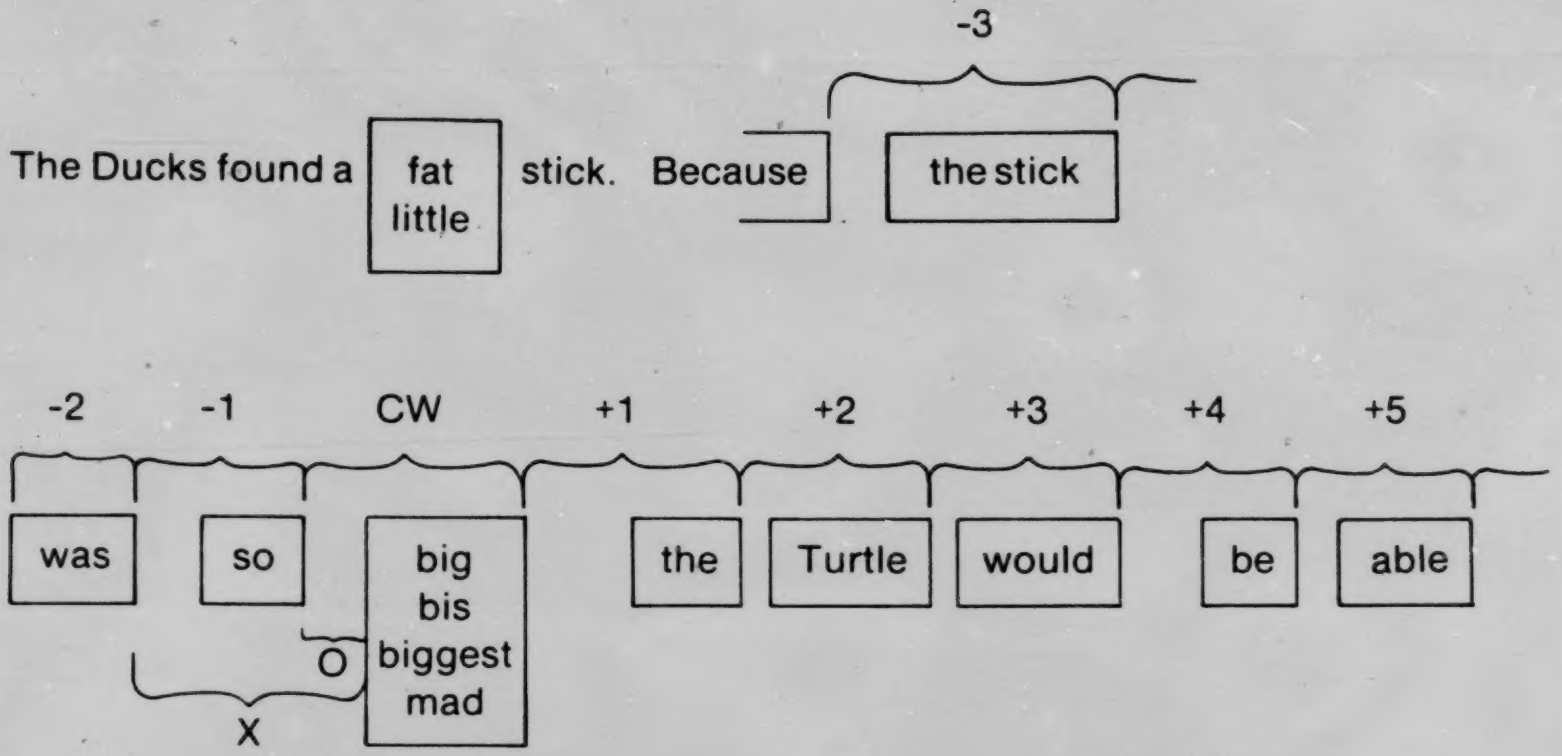
Materials. Stories were selected from primers not being used in the school system. Primers for one grade below the children's grades were used, i.e., stories from a first grade primer were selected for use with second graders, a story from a third grade primer for fourth graders, and a story from a fifth grade primer for sixth graders. The stories were rewritten to remove all conversation and to smooth out any other obvious problems with the stories. The stories selected were "The Turtle that Talked too Much" and "Homer Didn't Give a Hoot" for second graders, "Seal of Frog Island" for fourth graders, and "Star Island" for sixth graders. Two stories were needed for the second graders because no single story from the first grade primer was long enough. The stories were 881, 1354, and 1617 words long for the second, fourth, and sixth grade, respectively, and the readabilities (Fry, 1968) were 1.6, 3.5, and 5.6, respectively. The stories were divided into four sections (two for each of the second grade stories) and five critical words were selected in each quarter. The first critical word was 33, 68, and 38 words from the beginning of the story for the second, fourth, and sixth grade stories, respectively, and the critical words averaged 43, 66, and 79 words between them, respectively.

Lexical, syntactic, semantic, and factual violations were developed for each critical word following the same criteria as were used for the skilled reader texts. A sample segment from a second grade story is shown in Figure 7 with each of the modifications indicated as in Figure 1. The only change in the violation criteria was with the syntactic violation. In many instances, changing the part of speech of a critical word while retaining the base morpheme yielded a word that would not be known to the children. So many of the syntactic changes left the part of speech the same but violated some other syntactic rule, e.g., number agreement, adjectival comparisons, or verb mode. As the results demonstrated, these less radical changes were still disruptive to children's oral reading.

Five versions of each story were developed such that across versions each violation occurred once with each critical word segment and once in each quarter of each version. The second and fourth grade stories were typed on a primary typewriter having capitals 5/32" high. There were 8 and 10 letters per inch and lines were 7/8" and 1/2" apart for the second and fourth grade texts, respectively. The sixth grade story was typed on a standard typewriter with pica type (3/32" capitals, 10 letters per inch) using double spacing (7/16") between lines. A critical word did not occur within three words of the beginning or end of a line and did not occur in either the first or last lines of a page. The critical word segments with all changes for all three stories are presented in Appendix B, as they were developed for Experiment 5. There were some changes between Experiments 4 and 5, primarily in the factual inconsistencies, but the basic stories remained the same.

Subjects. For Experiment 4, the subjects were 17 second graders (8 boys and 9 girls), 18 fourth graders (9 boys and 9 girls), and 10 sixth graders (2 boys and 8 girls) from the Kent (Ohio) Public Schools. Twelve additional second graders (8 boys and 4 girls) were tested but were not included in the analysis because the story was too difficult to yield any useful data. Standardized reading test scores were not available, but teachers indicated that all children were at or above grade level in reading.

For Experiment 5, 50 children from two different elementary schools in the same school system were tested at each grade level. There were 21 male and 29 female second graders, 24 male and 26 female fourth graders, and 19 male and 31 female sixth graders. In addition, 18 (7 boys and 11 girls) second graders, 7 (4 boys and 3 girls) fourth graders, and 14 (7 boys and 7 girls) sixth graders were not included in the final sample because the text was too difficult for them or because of procedural errors. As in Experiment 4, standardized reading test results were not available, but all children were apparently at or above grade level in reading skill.



to hold on better. . . .

Figure 7. A portion of a story for second graders illustrating the different types of textual manipulations.

Procedure. Approximately equal numbers of children of each sex were tested on each version of the stories. Each child was tested individually in an isolated room in his/her own school during the school day. The child was seated at a table with a microphone and the experimenter was seated next to him/her. The child was put at ease with informal conversation with the experimenter (a female elementary school teacher). The children were told that the purpose of the test was to study how children understood stories. The children were asked to read each story aloud into the microphone. After reading each quarter of the story, the experimenter asked three or four preplanned simple, literal questions about the story in order to insure that the child was paying attention to meaning. They were given as much time as needed to read the story. If they asked any questions during the story, particularly about the pronounceable nonwords, the experimenter encouraged them to do the best they could. Any child who had difficulty with the experimental stories was given an extremely easy preprimer story at the conclusion of testing to build confidence. The entire session was tape recorded for later analysis.

Analysis. Three word units before the five word units after the critical word were defined as for skilled readers. However, since the children read more slowly there was less difficulty with coarticulation and so the large majority of word units were single words. The mean numbers of words per word unit were 1.06, 1.06, and 1.08 for the second, fourth, and sixth grade stories, respectively. The word units are marked on the segments in Appendix D.

Production times and major disruptions were scored exactly as they were with skilled readers. Analyses of variance of both dependent variables were identical in design to that used for the skilled readers with the addition of a between-subject factor of grade (second, fourth, or sixth). Extremely long production times (greater than 5 sec.) were truncated to 5 sec. Less than 1% of the times were truncated. Because Experiment 4 was a pilot study, production times were not scored nor were major disruptions analyzed statistically. The results from Experiment 4 are presented descriptively for comparison only.

Results and Discussion

Experiment 4. The frequencies of a major disruption for each grade level in the pilot experiment are presented in Table 6. The differences between the experimental and control conditions in the probability of a major disruption are presented in Table 7. In all three grades there was a sharp peak of disruption occurring at the critical word for the lexical, syntactic, and semantic violations. These peaks were much larger in absolute size than those obtained with college student readers.

Table 6

Experiment 4: Total Number of Major Disruptions

	Word Unit Position								
Violation	-3	-2	-1	0	+1	+2	+3	+4	+5
Second Grade (N = 17)									
Control	4	6	12	5	11	5	8	8	6
Lexical	7	4	12	53	22	10	9	7	5
Syntactic	3	7	12	58	20	8	10	5	4
Semantic	5	5	20	47	28	12	8	7	6
Factual	10	10	11	9	17	8	8	4	8
Fourth Grade (N = 18)									
Control	6	9	14	7	10	10	7	10	9
Lexical	8	12	26	63	26	28	12	8	6
Syntactic	6	11	26	57	19	10	10	14	10
Semantic	7	11	26	37	35	16	13	17	9
Factual	8	9	14	8	19	14	13	12	8
Sixth Grade (N = 10)									
Control	9	4	5	3	2	2	4	7	5
Lexical	6	4	12	27	12	8	8	6	2
Syntactic	5	7	11	33	4	7	4	7	6
Semantic	7	7	4	24	7	8	3	2	2
Factual	4	3	4	7	1	5	4	9	4

Table 7

Experiment 4: Differences between Experimental and Control Conditions in the Probability of a Major Disruption

	Word Unit Position								
Violation	-3	-2	-1	0	+1	+2	+3	+4	+5
Second Grade									
Lexical	.05	-.02	.02	.82	.18	.08	.02	-.01	-.01
Syntactic	-.01	.02	.01	.78	.14	.05	.03	-.04	-.03
Semantic	.02	-.01	.12	.62	.26	.11	.01	-.01	.00
Factual	.09	.06	-.01	.06	.10	.05	.01	-.05	.03
Fourth Grade									
Lexical	.03	.04	.17	.78	.22	.11	.07	-.03	-.04
Syntactic	.00	.03	.17	.70	.12	.00	.04	.06	.01
Semantic	.01	.03	.17	.42	.35	.08	.08	.10	.00
Factual	.03	.00	.00	.01	.12	.06	.08	.03	-.01
Sixth Grade									
Lexical	-.08	.00	.18	.60	.25	.15	.10	-.02	-.08
Syntactic	-.10	.08	.15	.75	.05	.12	.00	.00	.02
Semantic	-.05	.08	-.02	.52	.12	.15	-.02	-.12	-.08
Factual	-.12	-.02	-.02	.10	-.02	.08	.00	.05	-.02

Using a .10 difference in probability of a major disruption as a rough guideline, these disruptions diverged from the control condition at word unit -1 in several instances, i.e., semantic in the second grade, lexical, syntactic, and semantic in the fourth grade, and lexical and syntactic in the sixth. Furthermore, the disruption continued to word unit +1 in most cases, the only clear exception was syntactic in the sixth grade. The factual violation was only minimally disruptive with marginal effects at word unit +1 in the second and fourth grades and at the critical word in the sixth grade.

The pilot experiment confirmed the notion that oral reading is a reasonable procedure with which to study lexical access and comprehension in children learning how to read. The violations of the text were clearly disruptive to the children's oral performance. The only exception was the factual violation, but the small effect with a factual violation mirrored the skilled reader results. Some of the factual violations were modified for Experiment 5 in an attempt to strengthen the effect. A surprising result was the lack of any developmental trends in the patterns of disruptions. This result is examined more closely in Experiment 5. If it is supported, it suggests that the temporal structure of information use does not change appreciably as children learn how to read.

Experiment 5. The mean production times for each grade as a function of violation and word unit position are presented in Table 8. The differences between the experimental and control conditions in production times are shown in Figures 8, 9, and 10, for the second, fourth, and sixth grades, respectively.

Using both subjects and segments in a quasi-F test, the main effects of grade, F' (2, 162) = 21.857, MS_e = 4.046, violation type, F' (4, 206) = 67.569, MS_e = .945, and word unit position, F' (8, 420) = 35.426, MS_e = 1.042, were significant. There was a general decrease in reading times with increasing grade level. The violation and position effects can be interpreted only by reference to their interaction with each other, F' (32, 1608) = 18.592, MS_e = .896, with a critical difference between individual means of 107 msec. (The critical difference using only subjects in the error term was 57 msec.) However, the interaction of violation and position with grade level was not significant with the quasi-F test, F' (64, 1608) = .866, MS_e = .896, but it was significant using only subjects in the error term, F (64, 4320) = 3.095, MS_e = .251. The planned comparisons between individual experimental and control means were calculated at each grade level. The critical difference in means using both subjects and segments in the error term was 186 msec., and 98 msec. using only subjects in the error term.

The lexical, syntactic, and semantic violations had substantial effects on production times in all three grades (see

Table 8

Experiment 5: Mean Production Times (msec.)

	Word Unit Position								
Violation	-3	-2	-1	0	+1	+2	+3	+4	+5
Second Grade									
Control	614	518	496	303	675	454	574	668	647
Lexical	641	615	656	1898	1446	540	699	841	669
Syntactic	606	596	552	1176	1050	585	640	719	629
Semantic	642	542	612	908	1119	591	702	849	627
Factual	748	523	480	284	707	500	604	653	678
Fourth Grade									
Control	420	543	357	218	548	439	583	402	475
Lexical	464	614	553	1290	1161	550	694	457	556
Syntactic	428	485	473	746	880	486	689	419	475
Semantic	479	500	427	563	917	569	755	438	512
Factual	459	493	411	208	539	447	557	420	477
Sixth Grade									
Control	419	413	286	174	417	457	531	551	429
Lexical	385	501	380	1177	732	582	647	614	460
Syntactic	379	480	351	690	685	578	650	606	462
Semantic	399	451	332	602	643	540	655	674	532
Factual	412	451	327	268	430	489	564	556	465

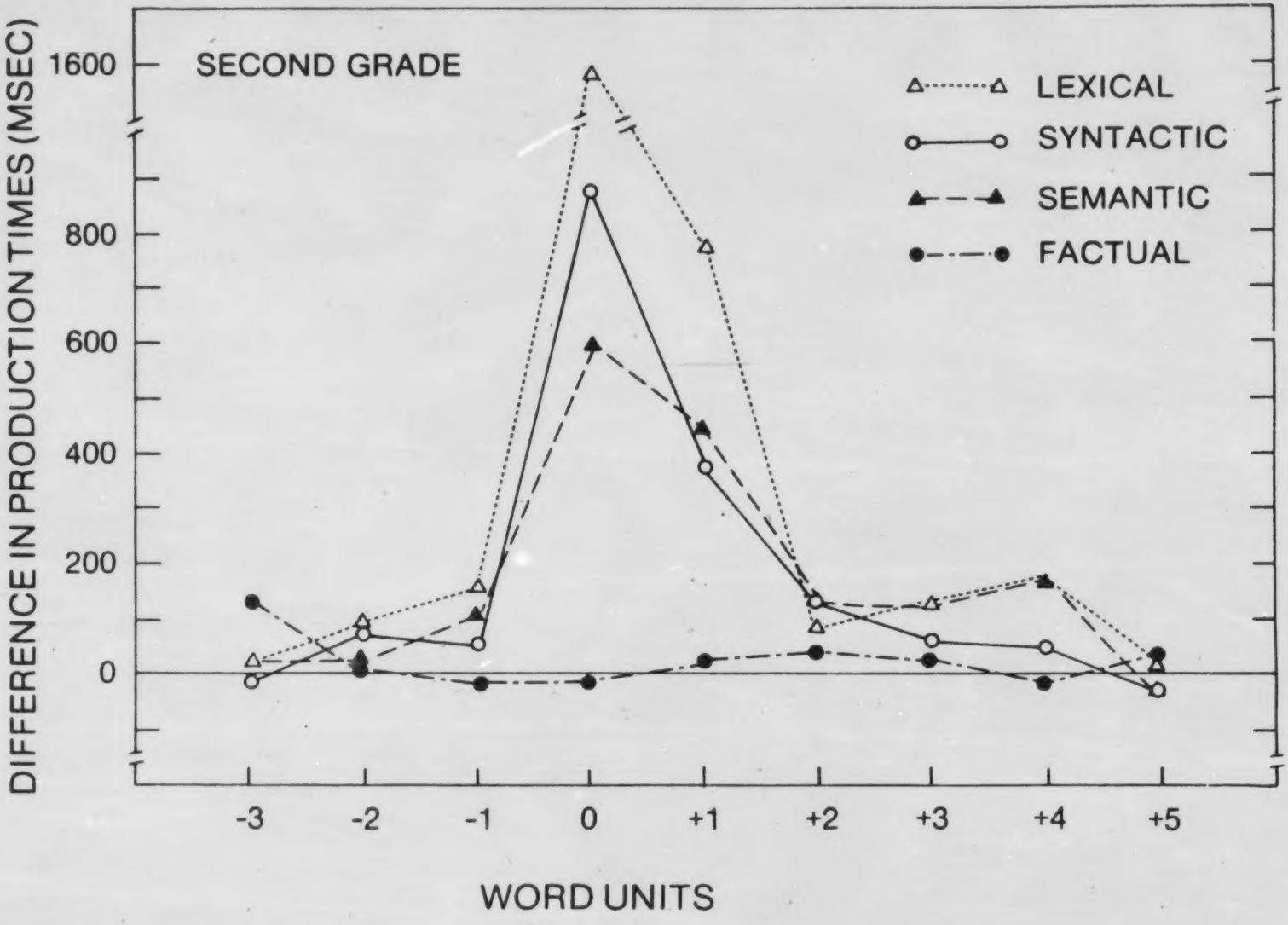


Figure 8. Experiment 5: Differences in second graders' production times.

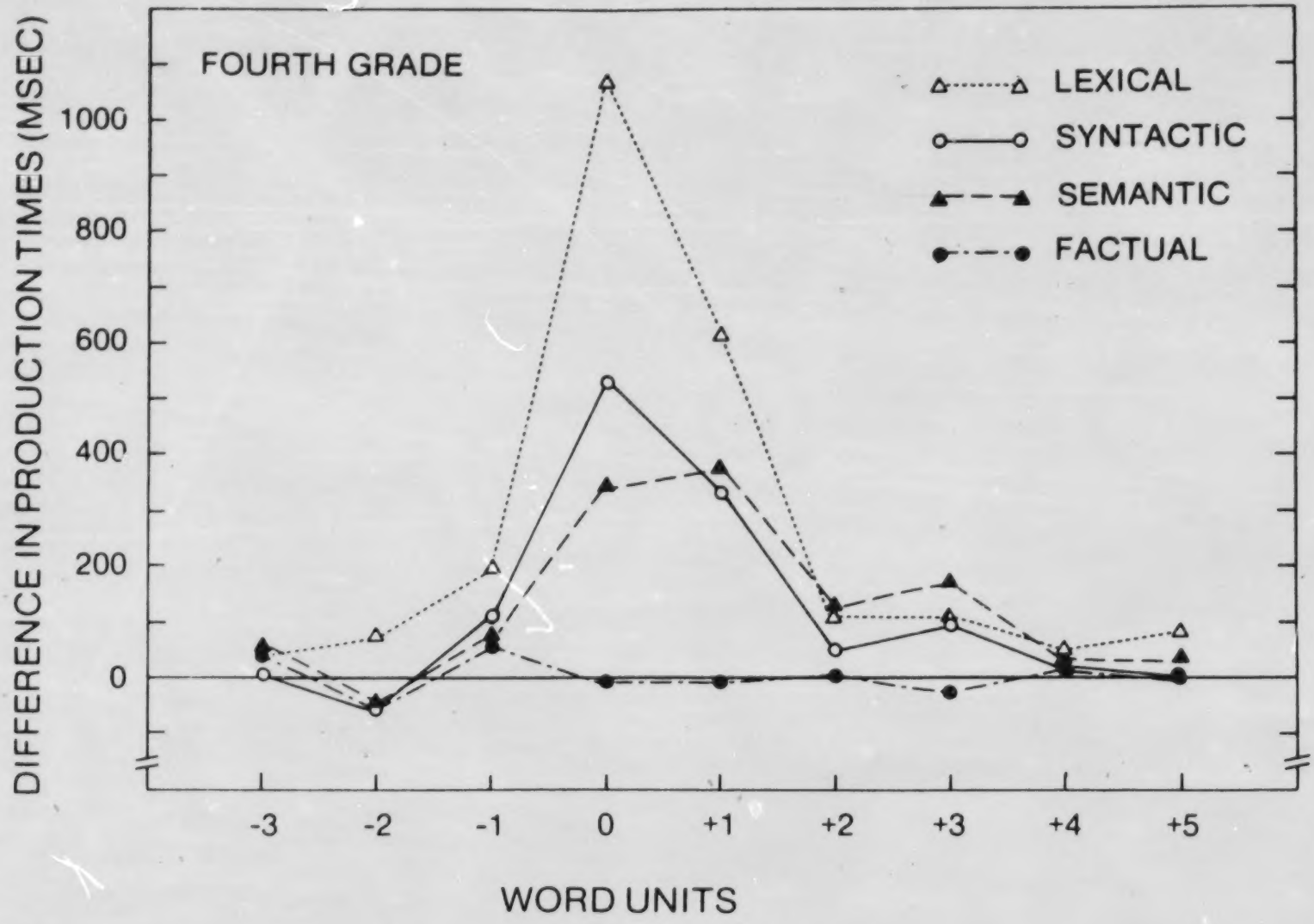


Figure 9. Experiment 5: Differences in fourth graders' production times.

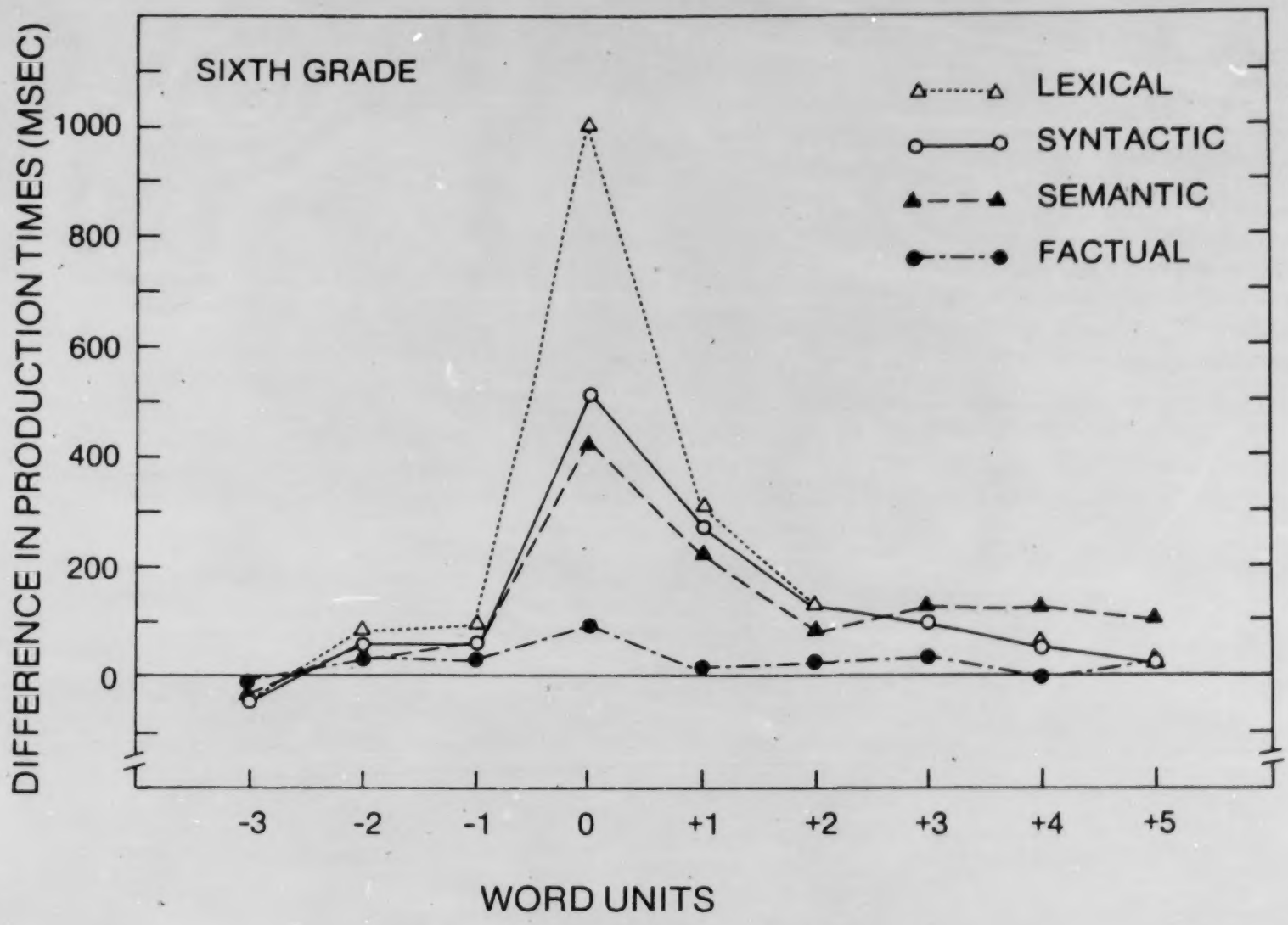


Figure 10. Experiment 5: Differences in sixth graders' production times.

Figures 8, 9, and 10). With the exception of the lexical violation at word unit -1 in the fourth grade, all three violations diverged from the control condition at the critical word in all three grades and were still having a disruptive effect at word unit +1. As indicated by the nonsignificant triple interaction of grade, violation, and position, the pattern of disruptions was essentially the same in all three grades. The factual violation was not significantly different from the control at any word unit position in any grade. Unlike the marginal disruption with skilled readers, the factual violations did not disrupt children's production times.

The frequency of major disruptions as a function of grade, violation, and word unit position are presented in Table 9. The differences in the probability of a major disruption between experimental and control conditions is depicted in Figures 11, 12, and 13, for the second, fourth, and sixth grades, respectively.

The main effect of grade was not significant in either the subjects or the segments analysis, F_{sub} (2, 135) = 1.667, MS_{sub} = 1.413, and F_{seg} = 2.740, MS_{seg} = 2.149. However, the main effects of violation and word-unit position as well as their interaction were significant in both subjects and segments analyses: violations, F_{sub} (4, 540) = 268.924, MS_{sub} = .400, and F_{seg} (4, 180) = 128.309, MS_{seg} = 2.098; word-unit position, F_{sub} (8, 1080) = 422.391, MS_{sub} = .561, and F_{seg} (8, 360) = 296.771, MS_{seg} = 1.997; and violation by position, F_{sub} (32, 4320) = 65.468, MS_{sub} = .457, and F_{seg} (32, 1440) = 35.176, MS_{seg} = 2.125. The triple interaction of grade with violation and position was significant in the subjects analysis, F_{sub} (64, 4320) = 1.746, MS_{sub} = .457, but not when segments was used as the error term, F_{seg} (64, 1440) = .938, MS_{seg} = 2.125. The planned comparisons of individual means were calculated using a F test. The critical differences between individual mean proportions were .066 in the subjects analysis and .090 in the segments.

Although there were some differences across the three grades, the results were very similar. Lexical, syntactic, and semantic violations all produced their largest disruptions at the critical word itself, and to a lesser extent at word unit +1. A few of the conditions were significantly different from the control as early as word units -2 or -1, i.e., lexical in sixth at -2, lexical in second and fourth at -1, syntactic in fourth and sixth at -1, and semantic in second and fourth at -1. Likewise, there were a few significant effects at word units +2 and +3, i.e., syntactic in second at +2 and semantic in fourth at +2 and +3. But the dominant effect was at and immediately after the critical word.

The factual violation produced small but significant disruptions in all three grades--at word unit +1 in the second

Table 9

Experiment 5: Total Number of Major Disruptions

	Word Unit Position								
Violation	-3	-2	-1	0	+1	+2	+3	+4	+5
Second Grade									
Control	17	14	18	24	31	14	17	16	12
Lexical	25	24	38	138	118	26	21	28	12
Syntactic	19	25	32	160	80	32	13	17	14
Semantic	22	22	42	134	102	31	27	22	9
Factual	22	23	24	34	51	21	22	11	11
Fourth Grade									
Control	12	28	14	26	19	20	19	13	16
Lexical	8	34	39	156	128	25	30	12	25
Syntactic	6	27	38	142	99	29	32	25	13
Semantic	15	26	34	93	99	38	42	11	19
Factual	17	29	26	33	40	23	17	16	19
Sixth Grade									
Control	22	28	25	15	26	19	23	13	12
Lexical	22	47	36	156	96	35	27	26	21
Syntactic	18	45	49	146	90	29	33	23	18
Semantic	23	45	30	111	84	28	35	31	18
Factual	23	41	29	42	37	18	30	26	17

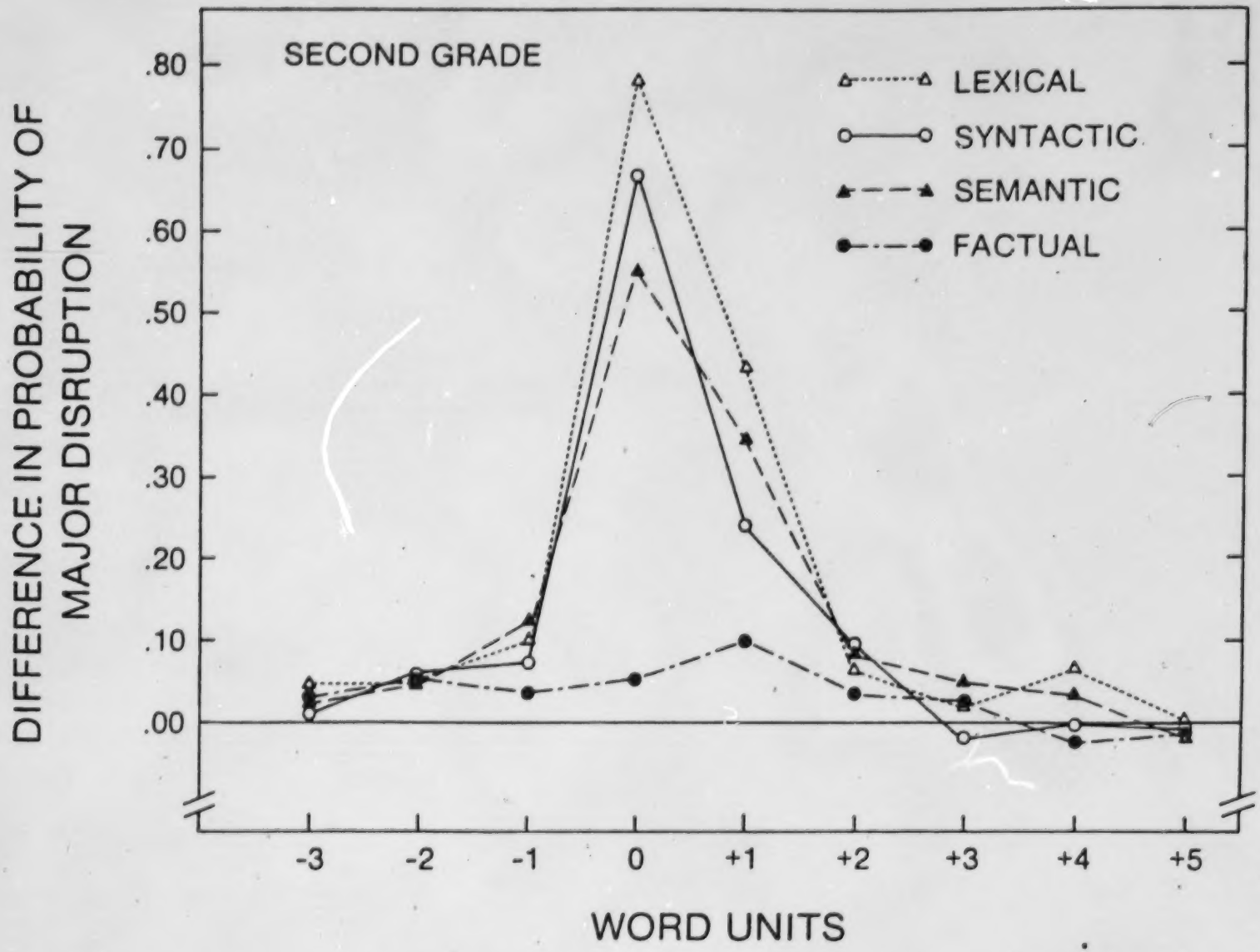


Figure 11. Experiment 5: Differences in second graders' probability of a major disruption.

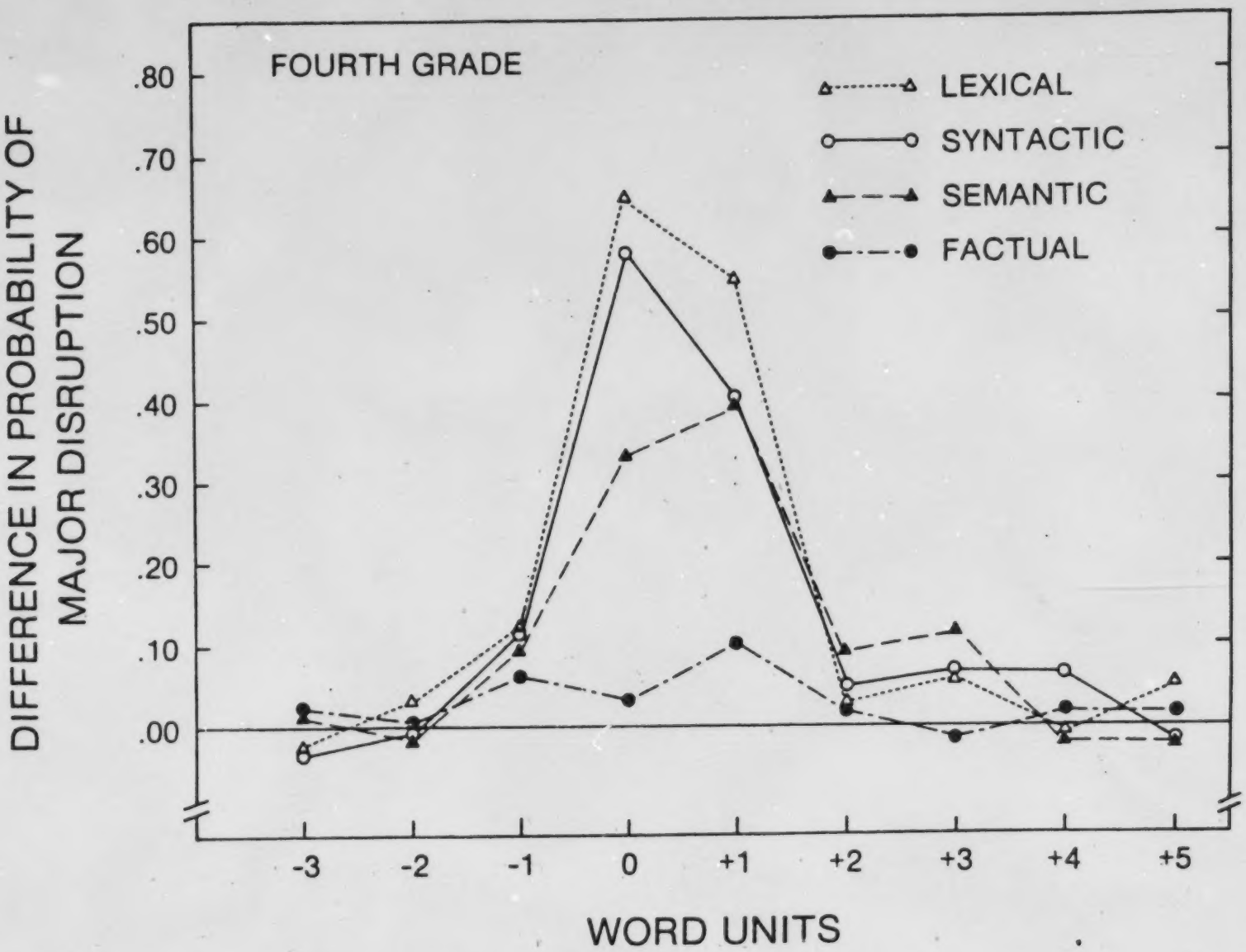


Figure 12. Experiment 5: Differences in fourth graders' probability of a major disruption.

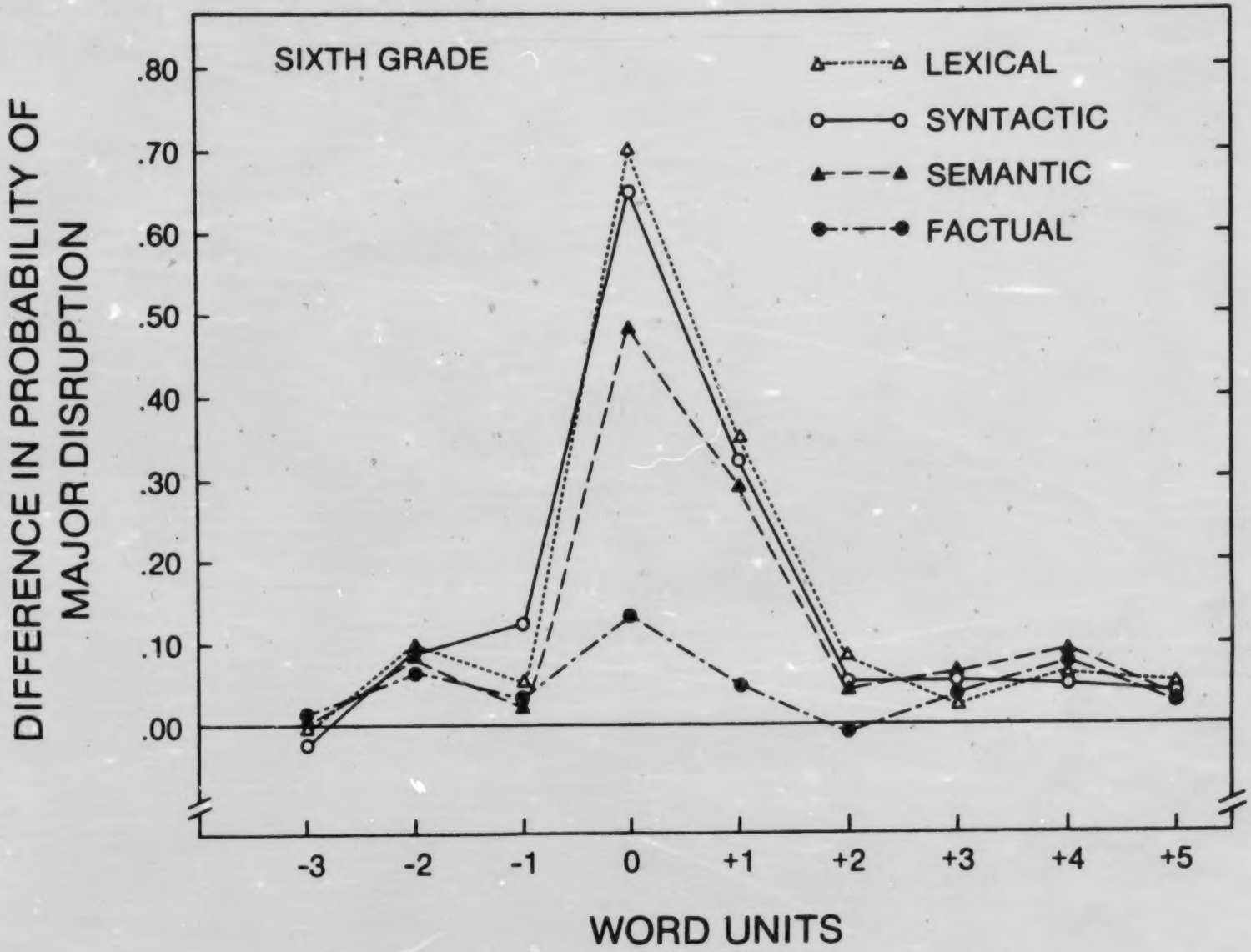


Figure 13. Experiment 5: Differences in sixth graders' probability of a major disruption.

and fourth grades and at the critical word in grade six. Factual information may have been filling some useful role in lexical access for the sixth graders, but not for the second and fourth. The small size of the children's factual disruption combined with the fact that the factual disruption was at +1 in skilled readers indicates that resolving a factual inconsistency is most critical at meaning construction, rather than at lexical access.

The major disruptions were analyzed qualitatively by separating different types of disruption. The major categories of disruptions were pauses, substitutions, mispronunciations (including stammerings and partial attempts), repetitions, and other miscellaneous disruptions. Since there were no significant effects at word units -3 and -2 and at word units +3, +4, +5, disruption frequencies at these positions were combined. The probability of a reader committing a particular type of disruption was calculated at each word unit position for each type of disruption. The control probabilities were subtracted from the violation conditions to yield a difference score reflecting the disruptive impact of the violation.

The mean probability of each type of major disruption is presented in Table 10. There were virtually no differences across grade as one would expect from the overall results, so the mean probabilities have been collapsed across grade in Table 10. Because most the the probabilities were so small, no statistical analyses were performed, but based on prior analyses we assume that differences of .10 or larger are probably reliable. These probabilities do not total to those in the overall analysis because there only one major disruption was scored at each position even though more than one type of disruption might have occurred. For example, if the reader paused and then substituted a different word for the critical word, one talley was entered in the overall analysis, but in this analysis a talley was entered both for a pause and for a substitution.

For the lexical violations, there were pauses before word unit -1 as well as before the critical word and immediately after it. There were some mispronunciations, as one might expect for a nonsense word. In scoring mispronunciations, any of several pronunciations that followed English phonography were accepted as correct. The mispronunciations were primarily stammerings and false starts on attempts to pronounce the nonword. Somewhat surprizingly, readers did not insert real words for the nonword to any appreciable degree, but they did repeat the word unit following the nonword (word unit +1). Perhaps this repetition was to give themselves time to figure out what was meant, or to establish a new beginning after the nonsense word.

There were some pauses before and after the syntactic violation, but a dominant response was a substitution. As

Table 10

Experiment 5: Probability of Different Types of Disruptions

Type of Disruption	Word Unit Position					
	-3,-2	-1	0	+1	+2	+3,+4,+5
Lexical Violation						
Pause	.03	.10	.64	.39	.05	.02
Substitution	.00	-.01	.02	.00	-.01	.00
Mispronunciation	.00	.01	.21	.03	.01	.00
Repetition	.00	.01	.04	.10	.00	.00
Other	.00	.00	.02	.01	-.01	.00
Syntactic Violation						
Pause	.02	.07	.25	.23	.07	.02
Substitution	.01	.00	.32	-.01	.01	.00
Mispronunciation	.01	.02	.14	.01	.00	.00
Repetition	-.01	.02	.12	.16	.01	.01
Other	-.01	.01	.00	-.01	-.01	.00
Semantic Violation						
Pause	.02	.09	.33	.35	.08	.04
Substitution	.01	-.01	.05	.00	.00	.00
Mispronunciation	.00	.01	.15	.01	.01	-.01
Repetition	.00	.00	.04	.04	.01	.01
Other	-.01	.00	.01	-.01	-.01	.01
Factual Violation						
Pause	.04	.02	.07	.12	.05	.03
Substitution	-.01	-.01	-.01	.00	.00	-.01
Mispronunciation	.00	.02	.01	.01	.00	.00
Repetition	.00	-.01	.02	-.01	.00	.00
Other	-.01	.00	.01	-.01	-.01	.00

with the adults, 38% of all major disruptions were substitutions that restored the syntactic form of the critical word. There also were a few mispronunciations and repetitions.

The semantic and factual violations yielded fewer different types of disruptions. Both produced pauses immediately before and after the critical word. The readers recognized that something was amiss and paused to try to figure it out. There also were a few mispronunciations of the critical word in the semantic condition.

The major conclusion is that syntactic and semantic information was nearly as influential in determining lexical access of the critical word as was lexical information itself. The magnitude of the effects were ordered from lexical violations producing the largest disruption, followed closely by syntactic and semantic violations. Perhaps these children were well along the way to skilled reading comprehension, so that bottom-up processing was relatively automatic, thus permitting top-down processes to operate. Their reading rates indicated that this was not the case, however. Estimating reading rates from the control condition, the second graders read at 123 syllables/minute, fourth graders at 161 syllables/minute, sixth graders at 181 syllables/minute, and college students (average of Experiments 2 and 3) at 270 syllables/minute. The children's reading on the whole was not as fluent as skilled readers. They read much more slowly and haltingly.

Comparing the children's results with those from skilled readers did not indicate any differences in processing as a function of skill level. These particular children may have been more highly skilled than one would expect from their grade level (standardized reading test scores were not available), but still they were not reading at adult levels. The use of relatively easy, age-appropriate texts may have aided the use of more skilled reading processes. Also some of the children's inefficiencies may have been masked by their slow reading rates. Whatever the reasons, syntactic and semantic information was operated on in conjunction with lexical information to obtain lexical access, but factual information was not a major factor.

General Discussion

As described in the Introduction, oral reading performance reflects two primary demands on the reader: lexical access and comprehension-integration. Lexical access is required so that the reader has the phonological code available to direct oral production. The reader also must understand what he/she is reading and integrate a coherent representation in order to satisfy the recall demand.

Disruptions in oral performance that occurred before or at production of the critical word were indicative of difficulties the reader may have been having with lexical access. This interpretation was most evident with the lexical violation because the reader was unable to locate the nonword in his/her mental dictionary. Hence, there was no phonological code to direct articulation. Also, there was no meaning that the reader could use to integrate in the meaning of the sentence. With the other violations, it is possible to think that the disruption of oral performance reflected a disruption in the underlying comprehension process. Since the disruption was maximal at the critical word for the syntactic and semantic violations just as it was for the lexical violation, it seems likely that these disruptions reflected lexical access and not meaning integration. Disruptions after the critical word was uttered, however, reflected the difficulties the reader was having with meaning integration. He/she obviously had accessed the word because he/she had said it. While all violations disrupted the meaning integration process, the factual violation had its only effect on meaning integration.

How the results of these experiments bear on understanding the cognitive processes readers use to satisfy these two demands is discussed in successive sections concluding with a brief section on the acquisition of reading skill.

Lexical Access

There are two interactive models that seem particularly applicable to the experiments: Rumelhart's (1977) parallel-interactive model of reading and Marslen-Wilson and Welsh's (1978) direct access model. Rumelhart's model depicts the reading process at all levels from visual features to semantic structures, although his discussion and examples emphasize word recognition. Marslen-Wilson and Welsh's model derives from experiments on speech shadowing rather than on reading, but it focuses exclusively on lexical access.

Rumelhart's Parallel-Interactive Model. Rumelhart postulated a neutral message center in which knowledge sources enter hypotheses about the visual input. The knowledge sources represent different levels of information that are represented in a text, e.g., letter features, letters, lexical, syntactic, and semantic information. The message center is a working memory buffer. All knowledge sources have access to all hypotheses entered there by other know-

ledge sources. Each knowledge source searches for information and hypotheses that will support its own hypotheses. Once sufficient support is garnered at a given level, a hypothesis is accepted as a true representation of the input. Since hypotheses can be entered by any knowledge source at any time, both bottom-up and top-down effects are possible.

Rumelhart's model covers many of the findings of the oral reading experiments. No lexical level hypotheses were able to be confirmed with the nonword violation. Featural, letter, and letter cluster hypotheses could be confirmed readily for the nonword, but these failed to provide sufficient evidence for any lexical hypothesis. There was syntactic and semantic contextual evidence for some lexical hypotheses, perhaps even the original critical word. But none of these hypotheses received sufficient bottom-up support to be accepted. At this point the reader balked and his oral reading performance was disrupted.

Syntactic and semantic violations had two effects. Bottom-up evidence supported a lexical-level hypothesis that did not receive contextual support from syntactic and/or semantic levels, making it difficult for the lexical hypothesis of the actually printed word to obtain sufficient support to be accepted. A second effect of syntactic and semantic violations was that inconsistent sets of hypotheses were formulated at those levels. One set of hypotheses was generated from hypotheses at lower levels. A second set was derived from hypotheses at the same and higher levels some of which were already confirmed. The former hypotheses were supported by bottom-up evidence, and the latter by contextual evidence, but neither could gather sufficient strength to be confirmed. Thus, the comprehension process was disrupted.

In these two effects of syntactic and semantic violations, we see the disruption of the oral performance task (the first effect) and of the comprehension task (the second effect). The disruption of the oral performance task was more pronounced given the demands of the oral reading task and so disruptions from the semantic and syntactic violations coincided with those from lexical violations.

The restoration of the correct part of speech when the grammatical inflection had been changed is a good example of how strong contextual support for a lexical hypothesis can override partially inconsistent bottom-up evidence. Most of the featural, letter, and letter cluster evidence from the root portion of the word was consistent with the contextual evidence from the syntactic and semantic levels. The partial direct support and the complete contextual support was sufficient in many instances to produce a correct restoration.

What we have called semantic and factual information are both included in Rumelhart's semantic knowledge source. However, given the large discrepancy in the location and size of the disruptions from the semantic and factual violations, they deserve to be separated. The factual level is evidently too distant to provide much support for or against hypotheses at the lexical level. In order for the comprehension task to be satisfied, a consistent set of hypotheses spanning all levels in the hierarchy had to be confirmed. Factual violations were disruptive because they did not allow the formulation of consistent hypotheses.

Marslen-Wilson and Welsh's Direct Access Model. The direct access model is closely related to Morton's logogen model of lexical access (Morton, 1969; Morton & Long, 1976). A logogen corresponding to each word fires when it has accumulated sufficient evident from the input and contextual sources to justify identification. Marslen-Wilson and Welsh (1978) modified the logogen model by making logogens active evaluators of available information, and by adopting an elimination criterion for recognition. An initial cohort of words (logogens) is activated by a preliminary analysis of the input. Each member of the cohort searches for additional bottom-up and contextual (top-down) information which might be consistent or inconsistent with that word. When inconsistent information is found, it removes itself from the cohort. When only one word remains it is recognized.

Marslen-Wilson and Welsh's direct access model provides a plausible account of the similarity in the disruption patterns from lexical, syntactic, and semantic violations. In all three conditions, direct visual processing of letter and letter cluster information activated a cohort of lexical possibilities. In speech only the initial phonemes are used to activate the initial cohort because the input of even a single word is sequential. In reading, however, information at any letter position can play a role in the initial activation. Activated items that were inconsistent with the contextual information (syntactic and semantic) deactivated themselves. The only item that was consistent with the bottom-up information was inconsistent with the contextual, and thus was eliminated. The reader was left with no active items in the cohort. When only the inflection had been altered (syntactic violation), the letters in the root provided enough bottom-up support to validate a restoration consistent with the higher-level information. This result is directly analogous to the restorations found by Marslen-Wilson (1975) in a shadowing task.

With a lexical violation, a cohort was activated by some of the letters and spelling patterns, but no word could be confirmed as bottom-up processing proceeded. Many of the intially activated cohort were eliminated on syntac-

tic and semantic grounds because they constituted an arbitray set.

As in Rumelhart's model, violation of factual information was less disruptive for lexical access because of the strong confirmatory bottom-up evidence and syntactic and semantic consistency. (Remember that sentences with factual violations were completely acceptable in isolation.) Oral performance could proceed apace because the lexical access task on which it depended was not disrupted.

The preferred lexical access model of oral reading is an amalgam of these two interaction models. Cohorts of lexical items are activated both by perceptual and letter information and by higher-level syntactic and semantic information. Fast top-down elimination of inconsistent possibilities yields a fast recognition if the word is in the cohort. However, if all the initial cohort is eliminated, then slower bottom-up processing is used to confirm a consistent alternative, if one is possible. A combination of confirmation and elimination criteria would make the evaluation process more efficient. Rapid elimination of obviously unacceptable items would reduce the initial cohort to a managable size for slower bottom-up confirmation. In many instances, bottom-up confirmation might be moot because all but one item are eliminated. Violation of lexical, syntactic, and semantic information leads to the complete elimination of the initial cohort, producing an immediate disruption, until slower careful bottom-up processing can resolve the difficulty. Because of the strength of the other information sources, factual inconsistency by itself is not sufficient to eliminate an item from the cohort.

Integration of Meaning

At some point in the comprehension process, the meanings of the individual words are integrated to form a representation of the clause, sentence, and larger units. Presumably, the syntactic structure of the sentence plays a major role in guiding how the word meanings are to be integrated, but the integration may be determined by semantic and pragmatic considerations instead (e.g., Schank, 1972; Winograd, 1972). Those investigators who emphasize the importance of syntactic constraints in meaning integration (e.g., Carroll & Bever, 1976; Carroll, Tanenhaus, & Bever, 1978) tend to assume that meaning integration occurs exclusively at the clause boundaries. It is only at the clause boundary that a complete syntactic structure is available to guide integration. At each clause boundary there is a qualitative shift in processing while integrative processes construct the meaning of the clause. After integration is complete, the meaning representations are integrated with those of preceding clauses. There is evidence documenting

the change in processing at the clause boundary (e.g., Bever, Garrett & Hurtig, 1973; Hurtig, 1978).

In the experiments reported here, the relation between the critical word and the next clause boundary was uncontrolled. Since the eye-voice span in skilled college student readers is roughly three to five words (Levin & Kaplan, 1970; Vazquez, Glucksberg, & Danks, 1977-1978), some of the disruptions in the studies with skilled readers may have been occurring at the clause boundary. The eye-voice span for children is less than for adults (Levin & Turner, 1968), increasing with reading skill. However, the clause boundaries in the children's texts in general were much closer to the critical word, so that it would be difficult to tease out whether the disruptions were at the clause boundary or not.

In order to assess whether the disruptions were occurring at the clause boundary in skilled readers, the number of words to the end of the underlying clause containing each critical word was determined in Experiments 2 and 3. For Experiment 2, the clause boundary fell immediately after the critical word (CB0), one word after the critical word (CB1), two or three words after the critical word (CB2-3), or six or more words after the critical word (CB6+) in each of four segments. For Experiment 3, the clause boundary fell immediately after six of the critical words (CB0), one word after three of the critical words (CB1), three words after three critical words (CB3), and six or more words after four of the critical words (CB6+). For each experiment the production time differences were plotted for each of the four clause boundary distances.

If the readers were waiting for the clause boundary to construct clausal meanings and to integrate them with the meanings of preceding clauses, then the disruptive effect would have been delayed progressively as the distance between the critical word and the clause boundary increased. For all three violations, the peak of disruption for CB0 (word unit +1) was one word unit earlier than for CB1 (word unit +2). At CB2-3 and CB3, there were two major peaks of disruption for most violations. One peak was at word units 0 or +1 and the other was at word unit +3, approximately at the clause boundary. With CB6+, there was a major peak at the critical word, but no second peak was detected because scoring stopped at word unit +5. Since the segments were no longer counterbalanced across condition, statistical analyses were not possible, but the peaks tended to be larger in magnitude than those depicted in Figures 3 and 5. In any case, conclusions based on these results must be quite tentative.

These results suggest that when the clause boundary was close to a critical word (CB0 and CB1), the reader attempted

to construct and integrate the meanings at the clause boundary. When the clause boundary was well beyond the critical word (CB6+), the reader attempted integration at a much earlier point, before he/she reached the clause boundary. With intermediate distances to the clause boundary (CB2-3 and CB3), integration was attempted at the critical word and at the clause boundary. These results are more consistent with a continuous word-by-word meaning integration, than they are with a clause boundary hypothesis.

Marslen-Wilson, and his associates (Marslen-Wilson, Tyler, & Seidenberg, 1978; Tyler & Marslen-Wilson, 1977) have proposed such a continuous word-by-word model of sentence meaning integration. As each word is recognized, the listener or reader attempts to integrate it with the representation he has already constructed from the preceding text. Sometimes integration can be only tentative and has to be changed when additional information is received from later portions of the sentence or text. This later adjustment can be noticed most clearly with ambiguous sentences where the disambiguating material appears after the ambiguity. Marslen-Wilson recognized that the modal place where a coherent representation can be formed is the clause boundary, not because of syntactic completeness, but because the idea being communicated is usually complete at that point. Although meaning representations typically can be finalized at the clause boundary, the listener or reader is attempting meaning integration as each word is recognized. Many times a complete representation has been formed by the time the clause boundary is reached, so that minimal additional processing is required at that point.

The tentative results of the clause boundary analysis of these experiments support the continuous word-by-word integration model. There was a disruption at or immediately after the critical word as the reader attempted to integrate the critical word's meaning with the growing representation. That attempt failed in the violation conditions. Thus, the critical word was left hanging, awaiting further information about how to integrate it, much like an ambiguous word that must await following information to be disambiguated. At the end of each clause, there was a second attempt to integrate the critical word's meaning because most of the possibly relevant information had been received at that point. A second failure yielded a second disruption at or around the clause boundary. That this double peaking was found with the factual violation is especially informative because the factual inconsistency was across a clause boundary. The critical word occurred at least one clause following the altered information that created the inconsistency. Even with the intervening clause boundary, there was disruption in the factual condition both at the critical word and at the next clause boundary. So the readers must have been

integrating the critical word with information from preceding clauses word continuously, word-by-word. Readers were constructing and integrating meanings of clauses and sentences at several different levels more or less simultaneously. Such multilevel interaction is the kind suggested by several investigators as supporting parallel-interactive models of comprehension (Danks, 1978; Lindig, 1976; Marslen-Wilson, 1975; Rumelhart, 1977).

Comprehension Processes During Learning to Read

The failure to find differences across grades in the patterns of disruption, reflecting development of reading processes while learning to read, was unexpected. Although a specific alteration in the pattern was not hypothesized, some sort of change in the pattern as children learned to read was expected. Very few studies that include a grade or skill variable fail to show development differences (e.g., Miller & Isakson, 1978).

Perhaps the slow reading rates of the children relative to the skilled readers masked differences in the disruption patterns. Because of the differences in reading rates and in the sizes of the word units, the word unit scale used on the x-axis in the figures represents different intervals. With slower reading rates of children, more time per word was available for processing so that the children's disruptions were compressed yielding apparently simultaneous disruptions. Although there may have been some compression of the effects in children, it is not as great as one might expect. Comparing average time per word unit across grades in the control conditions (i.e., a measure of how "big" the word units were in real time), second graders read at 581 msec/word unit, fourth graders at 471 msec/word unit, sixth graders at 438 msec/word unit, and college students (average of Experiments 2 and 3) at 487 msec/word unit. Only the second graders read appreciably more slowly, but a 100 msec difference is not a large enough compression to account for the failure to obtain grade differences.

A more likely explanation is that children use interactive processing in reading from the beginning, or at least develop it quickly. Most children use as many sources of information as they have available to access meanings and pronunciations of words and to integrate word meanings into comprehensive representations. At least by the middle of the second grade, they are not exclusively bottom-up or top-down processers. It is certainly possible that we missed changes in the acquisition of reading processes by beginning testing at the second grade. Other studies of oral reading have shown developmental progressions during the first grade (Biemiller, 1970; Cohen, 1974-1975). Whether these differences would show up as processing differences in the oral

reading task used here is uncertain. But even if differences did appear in first graders, an interactive processing strategy still develops rapidly.

Perhaps the interactive processes are evident because of the easiness of the stories. Readabilities of the stories were slightly below the children's grade levels. With relatively easy stories, more attention can be given to comprehension and the use of higher order information sources. With more difficult stories, texts that strain the reading process, children may have to revert to slower, more careful, bottom-up processing strategies. A common experience among skilled readers when reading a difficult passage is to read it subvocally, or even aloud. Presumably, the reason for doing this is to slow down processing and to direct attention to lower processing levels. By using easy stories, children may have been able to give relatively more attention to higher level information. One way to test this notion would be to give children more difficult texts so that their reading processes would be strained. If the above explanation is correct, then second graders should revert to reading like first graders when presented with a difficult text.

Finally, children may have demonstrated an interactive processing strategy at all grades because the experimental task deemphasized oral production accuracy and emphasized comprehension of the story. The experimenter never corrected any errors in the child's oral productions. Anything was accepted. The experimenter did, however, ask the child questions about what was read. If the child could not answer a comprehension question, the experimenter probed to see if the child could remember the answer. Classroom teachers, even if concerned with comprehension and meaning, are unlikely to let most oral production errors pass by. This different emphasis can affect what the child pays attention to in the text. Emphasis on correct oral productions decreases comprehension (Pehrsson, 1974). Our relative emphasis on comprehension may have led children to bias their processing toward higher levels of information.

References

Bever, T. G., Garrett, M. F., & Hurtig, R. The interaction of perceptual processes and ambiguous sentences. Memory & Cognition, 1973, 1, 277-286.

Biemiller, A. The development of the use of graphic and contextual information as children learn to read. Reading Research Quarterly, 1970, 6, 75-96.

Carroll, J. M., & Bever, T. G. Sentence comprehension: A case study in the relation of knowledge and perception. In E. C. Carterette & M. P. Friedman (Eds.), Handbook of perception: Language and speech, Vol. VII. New York: Academic Press, 1976.

Carroll, J. M., Tanenhaus, M. K., & Bever, T. G. The perception of relations: The interaction of structural, functional, and contextual factors in the segmentation of sentences. In W. J. M. Levelt & G. B. Flores d'Arcais (Eds.), Studies in the perception of language. Chichester: Wiley, 1978.

Cohen, A. S. Oral reading errors of first grade children taught by a code emphasis approach. Reading Research Quarterly, 1974-1975, 10, 616-650.

Danks, J. H. Models of language comprehension. Polish Psychological Bulletin, 1978, 9, 183-192.

Danks, J. H., & Fears, R. Oral reading: Does it reflect decoding or comprehension? In L. B. Resnick & P. A. Weaver (Eds.), Theory and practice of early reading, Vol. 3. Hillsdale, NJ: Lawrence Erlbaum Associates, 1979.

Danks, J. H., Fears, R., Bohn, L., & Hill, G. O. Comprehension processes in oral reading. Psychonomic Society, San Antonio, 1978.

Danks, J. H., & Hill, G. O. Interactive models of lexical access during oral reading. Conference on Interactive Processes in Reading, University of Pittsburgh, 1979.

Danks, J. H., & Miller, R. Comprehension processes in children's oral reading. Psychonomic Society, Phoenix, 1979.

Danks, J. H., & Glucksberg, S. Experimental psycholinguistics. Annual Review of Psychology, 1980, 31, 391-417.

Durkin, D. What classroom observations reveal about reading comprehension instruction. Reading Research Quarterly, 1978-1979, 14, 481-533.

Fears, R. Levels of processing in oral reading. Unpublished master's thesis, Kent State University, 1978.

Fears, R., & Danks, J. H. Levels of processing in oral reading. Midwestern Psychological Association, Chicago, 1977.

Fry, E. B. A readability formula that saves time. Journal of Reading, 1968, 11, 513-516, 575-578.

Hurtig, R. The validity of clausal processing strategies at the discourse level. Discourse Processes, 1978, 1, 195-202.

LaBerge, D., & Samuels, S. J. Toward a theory of automatic information processing in reading. Cognitive Psychology, 1974, 6, 293-323.

Levin, G., & Kaplan, E. L. Grammatical structure and reading. In H. Levin & J. P. Williams (Eds.), Basic studies on reading. New York: Basic Books, 1970.

Levin, H., & Turner, A. Sentence structure and the eye-voice span. In H. Levin, E. J. Gibson, & J. J. Gibson (Eds.), The analysis of reading skill. Washington, D.C.: U.S. Government Printing Office, 1968.

Lindig, K. D. Contextual factors in shadowing connected discourse. Unpublished doctoral dissertation, University of Chicago, 1976.

Marslen-Wilson, W. D. Sentence perception as an interactive-parallel process. Science, 1975, 189, 226-228.

Marslen-Wilson W., Tyler, L. K., & Seidenberg, M. Sentence processing and the clause boundary. In W. J. M. Levelt & G. B. Flores d'Arcais (Eds.), Studies in the perception of language. Chichester: Wiley, 1978.

Marslen-Wilson, W. D., & Welsh, A. Processing interactions and lexical access during word recognition in continuous speech. Cognitive Psychology, 1978, 10, 29-63.

Massaro, D. W. Primary and secondary recognition in reading. In D. W. Massaro (Ed.), Understanding language. New York: Academic Press, 1975.

Miller, J. W., & Isakson, R. L. Context sensitivity in beginning readers. Elementary School Journal, 1978, 78, 325-331.

Morton, J. Interaction of information in word recognition. Psychological Review, 1969, 76, 165-178.

Morton, J., & Long, J. Effects of word transitional probability on phoneme identification. Journal of Verbal Learning and Verbal Behavior, 1976, 15, 43-51.

Pehrsson, R. S. V. The effects of teacher interference during the process of reading or how much of a helper is Mr. Gelper? Journal of Reading, 1974, 17, 617-621.

Rumelhart, D. E. Toward an interactive model of reading. In S. Dornic (Ed.), Attention and performance VI. Hillsdale, NJ: Lawrence Erlbaum Associates, 1977.

Schank, R. C. Conceptual dependency: A theory of natural language understanding. Cognitive Psychology, 1972, 3, 552-631.

Tyler, L. K., & Marslen-Wilson, W. D. The on-line effects of semantic context on syntactic processing. Journal of Verbal Learning and Verbal Behavior, 1977, 16, 683-692.

Vazquez, C. A., Glucksberg, S., & Danks, J. H. Integration of clauses in oral reading: The effects of syntactic and semantic constraints on the eye-voice span. Reading Research Quarterly, 1977-1978, 13, 174-187.

Wildman, D. M., & Kling, M. Semantic, syntactic, and spatial anticipation in reading. Reading Research Quarterly, 1978-1979, 14, 128-164.

Winograd, T. Understanding natural language. Cognitive Psychology, 1972, 3, 1-191.

Footnotes

1. The introduction is based in large part on Danks and Hill (1979), a paper prepared for a Conference on Interactive Processes in Reading at the University of Pittsburgh.

2. Experiment 1 was conducted by Ramona Fears as part of a master's thesis submitted to Kent State University (Fears, 1978). It also was presented at a meeting of the Midwestern Psychological Association (Fears & Danks, 1977). The research was conducted before the beginning of the grant period, and was described in the original grant proposal. However, the oral reading tapes have been rescored to conform with the analytic procedures developed during the first year of the grant.

3. Experiment 2 was conducted by Lisa Bohn and has been reported at a meeting of the Psychonomic Society (Danks, Fears, Bohn, & Hill, 1978).

4. Experiment 3 was designed in collaboration with Lisa Bohn and was conducted by Jeff Hall. It has been reported at a meeting of the Psychonomic Society (Danks et al., 1978).

5. Experiments 4 and 5 were conducted by Ruth Miller and will be presented at a meeting of the Psychonomic Society (Danks & Miller, 1979). We acknowledge with grateful appreciation the cooperation of the Kent Public Schools, especially Mary Lou Phipps, elementary coordinator, and the principals, teachers, and students at Holden, Central, and Longcoy Elementary Schools.

Appendix A

Critical Word Segments for Experiment 1

Segment 1

```
          -5       -4        -3       -2        -1
. . . / down / the dark / aisles / and sat / on the /

                  0                    +1        +2       +3
(moss, glurck, school, killed) / beneath / the great / trees;

     +4         +5
/ and again / his mind / . . .
```

Segment 2

```
           -5         -4         -3       -2       -1
. . . / nostrils. / At first / the men / swore. / They /

                  0                              +1          +2
(struck, brugen, flew, brilliant) / and prodded / the camels.

   +3      +4      +5
/ Then / they / too / . . .
```

Segment 3

```
                -5                -4            -3      -2
. . . / the grinding, / the screaming. / He / wriggled /

  -1                        0                       +1        +2
in the / (dry, kaysen, brilliant, iron) / straw / stuffing /

   +3          +4         +5
his mouth / with it / to keep / . . .
```

Segment 4

```
             -5        -4      -3     -2         -1
. . . / crocodiles / were / shot / at, / the storks /

                  0                             +1          +2
(flew, glurck, killed, streets) / into the air/ in mass /

 +3          +4               +5
panic. / The beat of / their wings / . . .
```

Segment 5

```
          -5       -4          -3              -2
. . . / to his / knee / and removing / the binding /
```

-1 0 +1 +2
spread the / (cool, brugen, sharp, flew) / paste / thickly /

+3 +4 +5
on the / swollen / flesh. /

Segment 6

-5 -4 -3 -2 -1
. . . / town / and / entered it / and walked / through its /

0 +1 +2 +3
(streets, kaysen, iron, sharp). / Faces / looked at / him /

+4 +5
but he / did not / . . .

Segment 7

-5 -4 -3 -2 -1
. . . / struck / something / hard / and he / felt a /

0 +1 +2 +3
(sharp, glurck, cool, streets) / pain. / When he / looked up /

+4 +5
the train / was / . . .

Segment 8

-5 -4 -3 -2 -1
. . . / among / the dead. / Some of the / dead / had been /

0 +1 +2 +3
(killed, kaysen, ran, school) / by the / fire / and lay /

+4 +5
faceless / in the / . . .

Segment 9

-5 -4 -3 -2 -1 0
. . . / ships of / hard / fact, / of / hard / (iron, brugen,

+1 +2 +3 +4 +5
moss, cool), / of coal, / machinery, / cargo / and / tonnage. /

Segment 10

-5 -4 -3 -2 -1
. . . / behind, / a black / headland / notched / the /

0 +1 +2 +3
(brilliant, glurck, dry, moss) / sky. / Far ahead, / barely /

+4 +5
visible / in the / . . .

Segment 11

-5 -4 -3 -2 -1
. . . / from seven / to two / each / day / in the /

0 +1 +2 +3
(school, brugen, streets, ran) / itself. / Later / they /

+4 +5
went around / the town / . . .

Segment 12

-5 -4 -3 -2 -1
. . . / came, / in wild / summer / thunderstorms. / The rain /

0 +1 +2
(ran, kaysen, struck, dry) / down / his clothing, /

+3 +4 +5
plastering, / the dust / in streaks / . . .

Appendix B

Critical Word Segments for Experiment 2

Segment 1

Everyone in the Scott family was in high spirits because on Saturday they planned to fly to Mexico for a vacation.
(Everyone in the Scott family was depressed that morning because on Saturday they had to attend Mary Jane's grandmother's funeral.)

```
  -5          -4         -3      -2       -1                    0
No one/in the entire/Scott/family/was more/(excited, pumpkin,

           +1      +2              +3              +4        +5
smoked)/than/Mary Jane/an intelligent/and pretty/girl/.
```

Segment 2

Her daughter had always been weak physically.
(Her daughter had always been strong physically.)

```
            -5         -4        -3          -2       -1            0
Because/of this,/she even/imagined/her daughter/being/(trampled,

                       +1        +2      +3      +4      +5
iceberg, planted)/by other/children/while/trying/to get/ . . .
```

Segment 3

Sam Scott heard on the radio that morning that there had been a bus-train collision in . . .
(Sam Scott went to work and did not know that there had been a bus-train collision in . . .)

```
             -5                 -4       -3       -2        -1
. . . /Lawrenceville/.  Although/he was/relieved/that the/

                0                      +1        +2       +3
(accident, subtract, notebook)/had not/occurred/in his/

   +4        +5
community/he felt/ . . .
```

Segment 4

There was enough time for the school bus to slow down and yet it did not. A loud sound like a powerful explosion . . .
(The bus stopped at the stop sign and waited until the entire train had safely passed.)

```
          -5      -4     -3      -2     -1                    0
... / could be/heard/as the/train/and bus/ (collided, family,
```

+1 +2 +3 +4 +5
mailed)/. The train/hit/the bus/at the/midpoint/.

Segment 5

One boy had his left leg severed below the knee.
(One boy who was not injured was screaming hysterically.)

-5 -4 -3 -2 -1 0
She applied/a large/tourniquet/to stop/his/(bleeding, freeze,

+1 +2 +3 +4
writing)/leg/. Within minutes,/several ambulances/were on the/

+5
scene/.

Segment 6

They were unconscious and few had either . . .
(They were fully conscious and had either . . .)

-5 -4 -3 -2 -1
. . . /wallets/or purses/. Immediate/identification/was/(impos-

0 +1 +2 +3
sible, phonograph, athletic)/. Grabbing/a felt-tipped/pen,/

+4 +5
Dr. Carr/inscribed/ . . .

Segment 7

Mary Jane's name was first on a list of survivors.
(Mary Jane's name was first on a list of deceased.)

-5 -4 -3 -2 -1 0
She was/at that/moment/being/prepared/for/(surgery, summarize,

+1 +2 +3 +4 +5
trailer)/. From time/to time/a doctor/would enter/the cafe-

teria/ . . .

Segment 8

The doctor told the Scotts that the leg may have to be amputated as soon as a specialist could be found . . .
(The doctor told the Scotts that their daughter's leg may be saved as soon as a specialist could be found . . .)

-5 -4 -3 -2 -1 0
. . . /to perform/the surgery/. Vera/and Sam/were/(saddened,

```
                          +1          +2          +3      +4
rapidly, polished)/by this/possibility/. Vera/collapsed/

  +5
but Sam/ . . .
```

Segment 9

```
Once her vital signs stabilized, she was moved . . .
(In spite of the doctors efforts, her vital signs did not
stabilize which meant that she could not be moved . . .)

          -5       -4      -3     -2  -1                0
... /from her/hospital/room/. Mary/was/(carried, piano, printed)/

  +1    +2      +3        +4       +5
in her/bed/from the/intensive/care/ . . .
```

Segment 10

```
She was not aware of anything that happened to her . . .
(She was aware of everything that happened to her . . .)

 -5          -4           -3           -2              -1
after/the collision/of the bus/and the train/. She was/

                   0                        +1     +2     +3     +4
(unconscious, baseball, classical)/from a/blow/to the/ back /

  +5
of her/ . . .
```

Segment 11

```
Mr. Scott was shakened, but calm after all . . .
(Mr. Scott was shakened and dazed after all . . .)

             -5       -4        -3         -2      -1                    0
. . . /that had/happened/that day/. He had/clearly/(comprehended,

                         +1      +2       +3        +4        +5
umbrella, transported)/all/that the/doctors/had said/. The


Scotts/ . . .
```

Segment 12

```
On occasion, parts of her body would jerk uncontrollably as she. . .
(Her whole body was motionless as she . . .)

        -5     -4   -3       -2       -1                0
. . . /lay/in the/bed/. Her arm/and leg/(shook, money, spoke)/
```

+1 +2 +3 +4 +5
violently/. Her eyes/were closed/as though/she were/ . . .

Segment 13

The next day her temperature shot up over six degrees and perspiration and dehydration accompanied her high fever.
(The next day her temperature returned to normal and the perspiration and dehydration accompanying her high fever were gone.)

-5 -4 -3 -2 -1
As the hours/passed,/the nurses/continued/to change/her/

0 +1 +2
(sweat-soaked, accommodate, scuba-diving)/hospital/gowns/.

+3 +4 +5
For forty-eight/hours/her life/ . . .

Segment 14

Mary Jane became unusually more alert when she saw. . .
(Mary Jane rejected. . .)

-5 -4 -3 -2 -1
. . . /the special/drawing/board/. Immediately/she started/

0 +1 +2 +3 +4
(copying, divine, singing)/a picture/much/in the/style/

+5
of a/ . . .

Segment 15

She was allowed to have more visitors other than her immediate family.
(Although Mary Jane was now feeling better she was only allowed to have visitors from her immediate family.)

-5 -4 -3 -2 -1 0
Dozens/of her/classmates/came/to her/(bedside, punish, teeth)/

+1 +2 +3 +4 +5
in the/evenings/. To the/Scotts,/who had/ . . .

Segment 16

Ever since Mary Jane had been conscious and alert, she had been without exercise of any kind while in the hospital.
(Ever since Mary Jane had been conscious and alert, she was careful to exercise her muscles everyday while in the hospital.)

```
 -5    -4         -3          -2   -1           0
As a/result,/her muscles/started/to/(waste, fork, rejoice)/

 +1    +2      +3      +4       +5
away/. Now/with the/help/of three/ . . .
```

Appendix C

Critical Word Segments for Experiment 3

Segment 1

Everyone in the Scott family was in high spirits that morning because on Saturday they planned to fly to Mexico for a vacation.
(Everyone in the entire Scott family was depressed that morning because on Saturday they had to attend Mary Jane's grandmother's funeral.)

```
              -4       -3     -2      -1                  0
No one/in the entire/Scott/family/was more/(excited, smoked,

             +1     +2             +3            +4        +5
excitement)/than/Mary Jane/, an intelligent/and pretty/girl/.
```

Segment 2

Her daughter had always been weak physically.
(Her daughter had always been strong physically.)

```
                     -4       -3        -2        -1          0
Because of this/she even/imagined/her daughter/being/(injured,

                      +1       +2      +3    +4       +5
injury, planted)/by other/children/while/trying/to get out/. . .
```

Segment 3

Sam Scott heard on the radio that morning that there had been a bus-train collision in Lawrenceville.
(Sam Scott was not aware that there had been a terrible bus-train accident in Lawrenceville that morning.)

```
   -4      -3      -2       -1                    0
Although/he was/relieved/that the/(collision, collided, delusion)/

  +1       +2      +3      +4        +5
had not/occurred/in his/community,/he felt/ . . .
```

Segment 4

There was enough time for the school bus to slow down and yet it did not stop before . . .
(The bus driver saw the train just in time and miraculously stopped the bus before . . .)

```
          -4         -3         -2       -1            0
. . ./it reached/the tracks/. The bus/and train/(crashed,
```

```
                          +1        +2    +3     +4         +5
crashing, mailed)/and a loud/sound/like a/powerful/explosion/...
```

Segment 5

One boy had his left leg fractured below the knee.
(One boy was completely uninjured.)

```
                -4      -3     -2   -1              0
She applied/a large/splint/to fix/his/(broken, break, written)/

+1           +2           +3        +4         +5
leg/. Within minutes,/several/ambulances/were on/...
```

Segment 6

Most of them were unconscious and could not give their names to the . . .
(Most of them were conscious and had given their names to the . . .)

```
          -4          -3          -2          -1             0
. . . /physician/. Immediate/identification/was not/(possible,

                           +1          +2        +3     +4
possibly, athletic)/. Grabbing/a felt-tipped/pen,/Dr. Carr/

   +5
inscribed/...
```

Segment 7

Mary Jane's name was first on a list of survivors.
(Mary Jane's name was first on a list of deceased.)

```
                    -4    -3     -2     -1                 0
She was at that/moment/being/prepared/for/(surgery, surgically,

                +1       +2        +3        +4
trailer)/. From time/to time,/a doctor/would enter/ the

  +5
cafeteria/...
```

Segment 8

The doctor told the Scotts that the leg may have to be amputated as soon as a specialist could be found to perform . . .
(The doctor told the Scotts that the leg would be saved as soon as a specialist could be found to perform . . .)

```
          -4          -3    -2     -1                    0
. . ./the surgery/. Vera/and Sam/were/(depressed, depression,
```

+1 +2 +3 +4 +5
polished)/by this/possibility/. Vera/collapsed,/but Sam/ . . .

Segment 9

Unfortunately, her vital signs did not stabilize so it was impossible for the doctors and nurses . . .
(Fortunately, her vital signs had stabilized so it was possible for the doctors and nurses . . .)

-4 -3 -2 -1 0
. . . /to move/her/. Mary Jane/was/(carried, carrier, printed)/

+1 +2 +3 +4 +5
from the/intensive/care unit,/down the/corridor/.

Segment 10

After the collision of the bus and the train, she was not aware of anything . . .
(After the collision of the bus and the train, she was clearly aware of everything. . .)

-4 -3 -2 -1 0
. . . /that had/happened/to her/. She was/(unconscious, uncon-

+1 +2 +3 +4 +5
sciousness, classical)/from a/blow/to the/back/of her/ . . .

Segment 11

Mr. Scott was shakened but calm after all that had happened that day.
(Mr. Scott was so shakened and confused that he did not understand any of the medical explanations concerning his daughter's condition.)

-4 -3 -2 -1 0
All that the doctors/had told/him,/he had/clearly/(comprehended,

+1 +2 +3
comprehension, transported)/. The Scotts/were/overwhelmed/

+4 +5
with grief/. They realized/ . . .

Segment 12

On occasion parts of her body would jerk uncontrollably as she . . .
(Her whole body was completely paralyzed as she . . .)

-4 -3 -2 -1 0 +1
lay/in the bed/. Her arm/and leg/(shook, shaky, spoke)/violently./

+2 +3 +4 +5
Her eyes/were closed/as though/she were/ . . .

Segment 13

The doctor then informed Mary Jane's parents that the leg would have to be removed . . .
(The doctor then informed Mary Jane's parents that with more surgery, the leg would be able to be saved . . .)

-4 -3 -2 -1 0
. . . /completely/. After/Mary Jane's/leg was/(amputated,

+1 +2 +3 +4
amputation, amplified)/,she was/taken back/to her/room/in

+5
isolation/ . . .

Segment 14

Mary Jane became unusually more alert when she saw the special. . .
(Mary Jane rejected the special. . .)

-4 -3 -2 -1 0
drawing/board/. Immediately/,she started/(copying, copier,

+1 +2 +3 +4 +5
singing)/a picture/much/in the/style/of a/ . . .

Segment 15

She was allowed to have more visitors other than her immediate family.
(However, she still refused to have any visitors while she was bedridden.)

-4 -3 -2 -1 0
Dozens/of her/classmates/came/to her/(bedside, bedridden,

+1 +2 +3 +4 +5
teeth)/in the/evenings/. To the Scotts/who had seen/her/ . . .

Segment 16

Ever since Mary Jane had been conscious and alert, she had been without exercise of any kind while in the . . .
(Ever since Mary Jane had been conscious and alert, she was careful to exercise her muscles everyday while in the . . .)

-4 -3 -2 -1 0
. . . /hospital/. As a result/,her muscles/started to/ (waste,

+1 +2 +3 +4 +5
wasteful, rejoice)/away/. Now/with the/help/of three/ . . .

Appendix D

Critical Word Segments for Experiment 5

Grade 2

Segment 1

Once upon a time a Turtle lived on a pond with two Ducks.
(Once upon a time a Turtle lived in a barn with two Ducks.)

```
       -3  -2  -1                0                +1    +2
. . . /was/a/nice/(pond, tafe, ponds, paper)/for/fishing/.

 +3    +4    +5
They/were/happy/.
```

Segment 2

She had a lot to say.
(The Turtle liked the Ducks but she could not say anything to them.)

```
       -3  -2    -1                    0                 +1 +2
. . . /and/the/Ducks/(talked, taded, talker, potted)/a/lot/.

+3     +4     +5
The/Turtle/liked/ . . .
```

Segment 3

After a long time the pond began to dry up.
(Because of all the rain, there was water everywhere.)

```
        -3  -2  -1             0             +1   +2     +3  +4
. . . /pond/was/too/(dry, tog, dryer, ill)/the/Ducks/told/the/

  +5
Turtle/ . . .
```

Segment 4

The Ducks wanted to take the Turtle with them.
(The Ducks would have to leave the Turtle behind.)

```
        -3    -2     -1               0              +1     +2
. . . /that/they/would/(take, tate, taking, mix)/her/. But/

  +3      +4    +5
turtles/can't/fly/.
```

Segment 5

If the Turtle could keep still, they would let her go.
(If the Turtle could run fast, they would let her go.)

```
        -3   -2 -1                  0                  +1 +2
. . . /would/be/as/(still, sheld, stiller, purple)/as/she/

 +3   +4       +5
could/be/. The Ducks/ . . .
```

Segment 6

Because the Ducks told her to, the Turtle held the stick with her teeth.
(Because the Ducks told her to, the Turtle held the stick with her arms.)

```
        -3    -2  -1                   0                    +1
. . . /stick/with/her/(teeth, drosh, teething, leaf)/she would/

+2   +3  +4 +5
be/sorry/if/she/ . . .
```

Segment 7

The Ducks found a fat stick.
(The Ducks found a little stick.)

```
          -3     -2  -1             0               +1    +2
. . . /the stick/was/so/(big, bis, biggest, mad)/the/Turtle/

 +3   +4  +5
would/be/able/ . . .
```

Segment 8

As they flew above the trees, the Turtle shut her eyes.
(As they flew above the trees, the Turtle kept her eyes wide open.)

```
       -3   -2   -1                  0                    +1
. . . /her/eyes/were/(closed, thomed, close, cooked)/. She/

   +2    +3      +4      +5
thought/about/everything/the/ . . .
```

Segment 9

The bells were ringing.
(The bells were not ringing.)

```
        -3  -2  -1                0               +1   +2   +3
. . . /hear/all/the/(bells, biths, bell, rugs)/play/nice/music/.

    +4     +5
She wanted/to/ . . .
```

Segment 10

She saw trees and plants and there were many turtles.
(She saw trees and plants. But there were no turtles.)

```
-3  -2 -1                    0                        +1   +2  +3
One/of/the/(turtles, tanttes, turtle, trains)/asked/her/to/

 +4   +5
live/with/ . . .
```

Segment 11

Homer and Tom were all brown.
(Homer and Tom were all green.)

```
        -3   -2  -1                   0                  +1  +2
. . . /they/were/all/(brown, bines, browner, melted)/it/would/

+3  +4  +5
be/hard/to/ . . .
```

Segment 12

But they had to go visit a friend.
(Mother told Tom that she wouldn't leave them alone.)

```
       -3  -2    -1                   0                +1  +2
. . . /she/and/Father/(left, loth, leaving, burned)/for/two/

 +3      +4      +5
days/. Tom/and Homer/ . . .
```

Segment 13

Homer got ready for a nice long sleep in . . .
(Tom sat beside Homer sleeping in . . .)

```
           -3     -2   -1               0                +1
. . . /the nest/while/Tom/(flew, flan, fly, rained)/around/

+2   +3       +4  +5
the/woods/. Tom/knew/ . . .
```

Segment 14

Homer went right to sleep but when he woke up he was alone.
(Homer went to sleep and slept and slept all day long.

```
       -3    -2    -1                   0                   +1
. . . noon/he was/wide/(awake, anith, awaked, pushed)/looking/

+2  +3     +4    +5
for/Tom/. That/night/ . . .
```

Segment 15

He heard a big sound.
(He heard a soft sound.)

```
   -3     -2  -1              0                  +1  +2  +3    +4
The sound/was/so/(loud, losh, louder, wet)/that/it/made/Homer/

  +5
scared/.
```

Segment 16

Then Homer heard a noise.
(A mouse was coming up the tree.)

```
         -3   -2  -1            0                  +1   +2   +3 +4
. . . /tree/came/a/(cat, cos, cats, cake)/. What/would/he/do/?

  +5
Father/ . . .
```

Segment 17

As Tom flew in the nest, the cat was scared of Tom's bill.
(As Tom flew in the nest, the cat killed Tom with his claw.)

```
         -3   -2  -1                   0                       +1   +2
. . . /tree/with/Tom/(running, rasting, ran, baking)/after/it./

+3  +4  +5
The/cat/got/ . . .
```

Segment 18

Homer could not fly well.
(Homer could fly on the first try.)

```
          -3     -2      -1                    0                  +1
. . . /first/took off,/Homer/(fell, koth, falling, snowed)/to/

+2    +3     +4  +5
the/ground/. He/fell/ . . .
```

Segment 19

Homer told them that he wanted to show them something.
(Homer and Tom were asleep and Mother didn't wake them.)

```
          -3      -2     -1               0              +1  +2
. . . /Father/watched/Homer/(fly, tham, flew, drip)/over/the/

 +3     +4   +5
nest/. They/were/ . . .
```

Segment 20

The next day was just right for the family to go flying.
(The next day it was raining too hard for the family to go flying.)

```
  -3   -2  -1                0                  +1 +2  +3  +4
There/were/no/(clouds, chands, cloud, coats)/in/the/sky/as/

  +5
Mother/ . . .
```

Grade 4

Segment 1

One summer afternoon John was slowly walking on the . . .
(One summer afternoon John was asleep on the . . .)

```
         -3        -2     -1                   0
. . . /beach/. Suddenly,/he/(stepped, slonned, step, rotted)/

+1  +2  +3 +4      +5
on/what/he/had/thought/ . . .
```

Segment 2

John couldn't leave the baby seal alone.
(John wouldn't touch the baby seal.)

```
          -3  -2   -1                0              +1 +2     +3
. . . /cried/in/John's/(arms, nars, armed, dots)/as/he/carried it/

+4 +5
to/the/ . . .
```

Segment 3

The baby seal sniffed at the fish.
(The baby seal chewed up the fish.)

```
         -3  -2  -1           0              +1    +2    +3  +4
. . . /small/yet/to/(eat, ent, eaten, mop)/solid/food/. So/John/

  +5
carried/ . . .
```

Segment 4

John was awake at daylight the next morning.
(John ate and ran outside the next morning.)

```
         -3      -2    -1              0                 +1    +2
. . . /quickly/jumped/from/(bed, boh, bedding, bat)/because/he/
```

+3 +4 +5
wanted/to/see if/ . . .

Segment 5

Father told John that he could keep it.
(Father took the seal and left it on the mainland.)

-3 -2 -1 0 +1
. . . /safe/on/the/(island, cotate, islander, fence)/. He/

+2 +3 +4 +5
made/a/place/in/ . . .

Segment 6

Looking at John, the seal sniffed at the milk and it tried to drink.
(Looking at John, the seal wouldn't open its mouth.)

-3 -2 -1 0 +1 +2
. . . /eyes/the/seal/(sucked, solden, sucking, smoked)/the/milk/.

+3 +4 +5
John/gently/wiped/ . . .

Segment 7

Each day the baby seal grew stronger and stronger.
(But the seal became so weak it couldn't stand.)

-3 -2 -1 0
. . . /seal's/muscles/became/(powerful, pernsful, powerfully,

+1 +2 +3 +4 +5
jolly)/. The/seal/adopted/John/and/. . .

Segment 8

John discovered that Albert could not swim when they had an accident.
(John discovered that Albert was an expert swimmer when they had an accident.)

-3 -2 -1 0 +1 +2
The/seal/almost/(drowned, drined, drowning, drilled)/when/some/

+3 +4 +5
waves/turned/their/ . . .

Segment 9

Even though Albert wanted to swim, he would not swim alone.
(Albert hardly ever spent time with John now.)

```
        -3   -2    -1                              0
. . . /John/were/always/(together, tapothen, togetherness,

              +1      +2      +3  +4  +5
raining). Albert/thought/John/was/his/ . . .
```

Segment 10

One day, in the early morning, John took Albert fishing.
(One day, in the late evening, John took Albert fishing.)

```
        -3  -2    -1                                 0
. . . /time/for/Albert's/(breakfast, trontel, breakfasted,

            +1   +2    +3   +4  +5
winter)/. Once/John/caught/a/fish/ . . .
```

Segment 11

He held a fish in front of Albert and then threw it out into the waves.
(He held a fish in front of Albert and then threw it onto the sandy beach.)

```
       -3  -2 -1                        0                    +1   +2
. . . /and/on/the/(water, whons, watering, whistle)/and/swim/

 +3      +4   +5
away/. John/took/ . . .
```

Segment 12

Albert leaped back and forth in excitement.
(Albert leaped into the water to chase the fish.)

```
        -3    -2    -1              0            +1   +2
. . . /away/Albert/still/(sat, tas, sit, cut)/on/the beach/.

 +3  +4      +5
John/did/the same/ . . .
```

Segment 13

There was a shed behind the house with doors that were never locked.
(There was a shed behind the house but the doors were closed tight.)

```
        -3    -2   -1                  0               +1  +2
. . . /doors/were/wide/(open, noce, opening, numb)/so/that/

  +3      +4     +5
Albert/could/easily/ . . .
```

Segment 14

He saw two big fuel drums with round, smooth lids.
(He saw two small fuel drums with round, smooth lids.)

```
        -3    -2  -1                  0                    +1  +2
. . . /drums/were/so/(large, tengan, largest, sweet)/he/could/

  +3      +4  +5
easily/stand/on/ . . .
```

Segment 15

Albert thought this was even better.
(Afraid, Albert jumped and ran to the beach.)

```
       -3    -2   -1                  0                      +1  +2
. . . /hid/behind/the/(drum, drit, drumming, apple)/. John/was/

  +3      +4     +5
afraid/Albert/would/ . . .
```

Segment 16

But Father had awakened too and was listening to John scold Albert.
(But Father slept with earplugs so he couldn't hear anything.)

```
         -3      -2       -1                  0
. . . /in the/distance/Father/(heard, trond, hear, hatched)/

+1      +2    +3 +4   +5
the/who-who/of/a/ship's/ . . .
```

Segment 17

Father had also started to worry, so he jumped out of bed.
(Because Father was getting old, he now moved very slowly.)

```
         -3   -2 -1                  0                +1   +2
. . . /closer/as/he/(sped, spim, speeder, dripped)/to/the door/

+3  +4  +5
to/look/at/ . . .
```

Segment 18

Mother ran into the tower and started right to work on her job.
(All at once Mother tripped, hitting her head so hard that she fainted.)

```
       -3  -2  -1                    0                      +1
. . . /her/she/was/(running, ramting, runner, bowling)/to the/
```

+2 +3 +4 +5
door/to/look/at/ . . .

Segment 19

Albert ran too fast to greet John and turned over an open fuel . . .
(Albert ran too fast to greet John and turned over an empty fuel . . .)

-3 -2 -1 0 +1
. . . /drum/. As/gas/(poured, pentle, pouring, laughed)/out,/

+2 +3 +4 +5
there/was a/big/splash/.

Segment 20

Later, John and his family listened to their ship-to-shore radio as the captain praised Father for wasting the fuel.
(Later, John and his family listened to their ship-to-shore radio as the captain scolded Father for letting the light go out.)

-3 -2 - 1 0 +1
. . . /Father/received/a/(reward, rament, rewarded, mouth)/for/

+2 +3 +4 +5
saving/the/ship/and/ . . .

Grade 6

Segment 1

A yellow cat was sleeping in the sun.
(The moon was full and there were a million stars.)

-3 -2 -1 0 +1 +2
. . . /light/of/the/(sun, nos, sunning, stew)/made/everything/

+3 +4 +5
look/very/clean/. . .

Segment 2

Mrs. Apple led the way to the door of the freshly painted porch, stooping to pet Freckles the cat.
(Mrs. Apple led the way to the door of the freshly painted porch, showing them her prize rabbit, Freckles.)

-3 -2 -1 0 +1 +2
. . . /was/the/smartest/(cat, nad, cats, hat,)/in the/world/.

+3 +4 +5
Then/Larry/met/ . . .

Segment 3

His hand went out almost by itself.
(He put his hands in his pockets.)

-3 -2 -1 0 +1 +2 +3
. . . /lining/of/the/(ear, eth, earful, pea)/on/Mate's/huge/

+4 +5
head/. The/ . . .

Segment 4

This place was poorer than any place he had ever been.
(This was the first place Larry had ever wanted to stay.)

-3 -2 -1 0 +1 +2
. . . /would/let/him/(leave, laroe, leaving, glow)/this/awful/

+3 +4 +5
island/. He/sure/ . . .

Segment 5

Mr. Apple noisily entered the room.
(Mr. Apple walked to the field to clean the fish.)

-3 -2 -1 0 +1 +2
. . . /down/on/the/(floor, theer, floored, camel)/next/to/

+3 +4 +5
Larry/. Even/though/ . . .

Segment 6

Mr. Apple had only two easy questions for . . .
(In fact, Mr. Apple was too busy to talk to . . .)

-3 -2 -1 0
. . . /Larry/. Mr. Apple's/first/(question, possetes, questioned,

+1 +2 +3 +4 +5
queen)/was/to find/out/if/it/ . . .

Segment 7

After they saw how folks there lived, their minds were made up.
(The main island folk were very old-fashioned and backward.)

-3 -2 -1 0 +1
. . . /folk/were/very/(modern, manlet, modernly, minty)/. They/

+2 +3 +4 +5
had/TVs/and/movie/ . . .

Segment 8

There were footsteps and then a knock at the door.
(Larry watched Miss Carr leave in the rowboat.)

-3 -2 -1 0 +1
. . . /stepped/into/the/(house, hanor, housed, handbag)/and/

+2 +3 +4 +5
smiled/. Walking/over/to the/ . . .

Segment 9

Larry loved the taste of lobster.
(Larry hadn't eaten all day.)

-3 -2 -1 0 +1
. . . /because/he was/so/(full, fost, fullness, shiney)/of/

+2 +3 +4 +5
lobster/stew/. The Apples/didn't/ . . .

Segment 10

Mate scrambled over to romp with Pete.
(Thinking Larry in danger, Mate leaped to attack.)

-3 -2 -1 0 +1
. . . /dog/when/Mate/(licked, lonted, licker, lettered)/his/

+2 +3 +4 +5
face/. Everyone/was/laughing/. . .

Segment 11

Larry reluctantly went upstairs to put away his suitcase.
(Larry went upstairs to put away the clothes in his suitcase.)

-3 -2 -1 0
. . . /his/suitcase/was/(empty, erply, emptiness, windy)/.

+1 +2 +3 +4 +5
Pete/called/to/Larry/from/ . . .

Segment 12

He called Mate to walk with him.
(Mate willingly stayed with Larry.)

-3 -2 -1 0 +1 +2
. . . /left/with/the/(dog, dolp, dogging, diet)/at his/heels/.

```
 +3    +4      +5
Three/hours/later,/ . . .
```

Segment 13

Larry lay in bed with his eyes closed but couldn't sleep.
(Larry tried but couldn't sleep because of the wolves howling.)

```
          -3  -2 -1                  0                  +1    +2
. . . /used/to/the/(quiet, garne, quietly, quart)/of/the house/.

  +3      +4      +5
There/were no/sounds/ . . .
```

Segment 14

There wasn't a light on in town but the sky was full of lights of many sizes and shapes.
(There wasn't a light on in town and the clouds were so thick he couldn't see the moon.)

```
         -3  -2  -1                0                   +1     +2
. . . /seen/so/many/(stars, saets, starry, suds)/before/. By/

 +3     +4       +5
their/light/he could/ . . .
```

Segment 15

Larry could smell food coming from the kitchen, so he hurriedly dressed and went downstairs to see what was cooking.
(Larry went to the kitchen and found it empty but through the window he saw Aunt Emma plowing in the field with a tractor.)

```
        -3  -2 -1              0                   +1       +2
. . . /was/at/a/(stove, sline, stoves, jaw)/turning/blueberry/

   +3       +4  +5
pancakes/. If/they/ . . .
```

Segment 16

Larry forgot that he wasn't going to cooperate.
(Larry decided to refuse his offer.)

```
        -3  -2   -1                    0                        +1
. . . /eye/he/quickly/(agreed, apumed, agreement, bathed)/ with/

+2   +3    +4    +5
the/idea/. As/soon as/. . .
```

Segment 17

Uncle Joe had given Larry some clothes to wear and he was well prepared.

(Seeing the water, Larry remembered he was only wearing sandals that day.)

```
       -3 -2   -1                  0                +1  +2   +3
. . . /at/his/high/(boots, borts, booted, bowls)/and/oil/skins/

+4   +5
and/felt/ . . .
```

Segment 18

Larry untied the front rope so that the boat would be free to move out to sea.
(They still had two hours of work to do before this old tub would move.)

```
         -3     -2   -1                    0
. . . /minutes/they/were/(sailing, saching, sail, shopping)/

+1  +2  +3    +4   +5
out/to/sea/. I've/got a/ . . .
```

Segment 19

He started to reel the line in.
(As he pulled the line in it snapped.)

```
       -3   -2   -1                        0
. . . /the/line/was/(unbroken, entratan, unbroke, unaware)

+1    +2     +3   +4     +5
as/the trap/was/pulled/aboard/.
```

Segment 20

The sun was straight overhead now as they headed home.
(They turned the boat away from land and headed out to sea.)

```
          -3      -2    -1                       0
. . . /steering/towards/the/(shore, shrem, shored, scissors)/

  +1  +2  +3   +4     +5
Uncle/Joe/let/Larry/command/ . . .
```